UNCLASSIFIED AD NUMBER AD240849 LIMITATION CHANGES TO: Approved for public release; distribution is unlimited. FROM: Distribution authorized to U.S. Gov't. agencies and their contractors; Administrative/Operational Use; 10 AUG 1960. Other requests shall be referred to Army Transportation Research Command, Fort Eustis,

VA.

AUTHORITY

TRECOM ltr 21 Dec 1972

UNCLASSIFIED

AD 240849

Reproduced by the

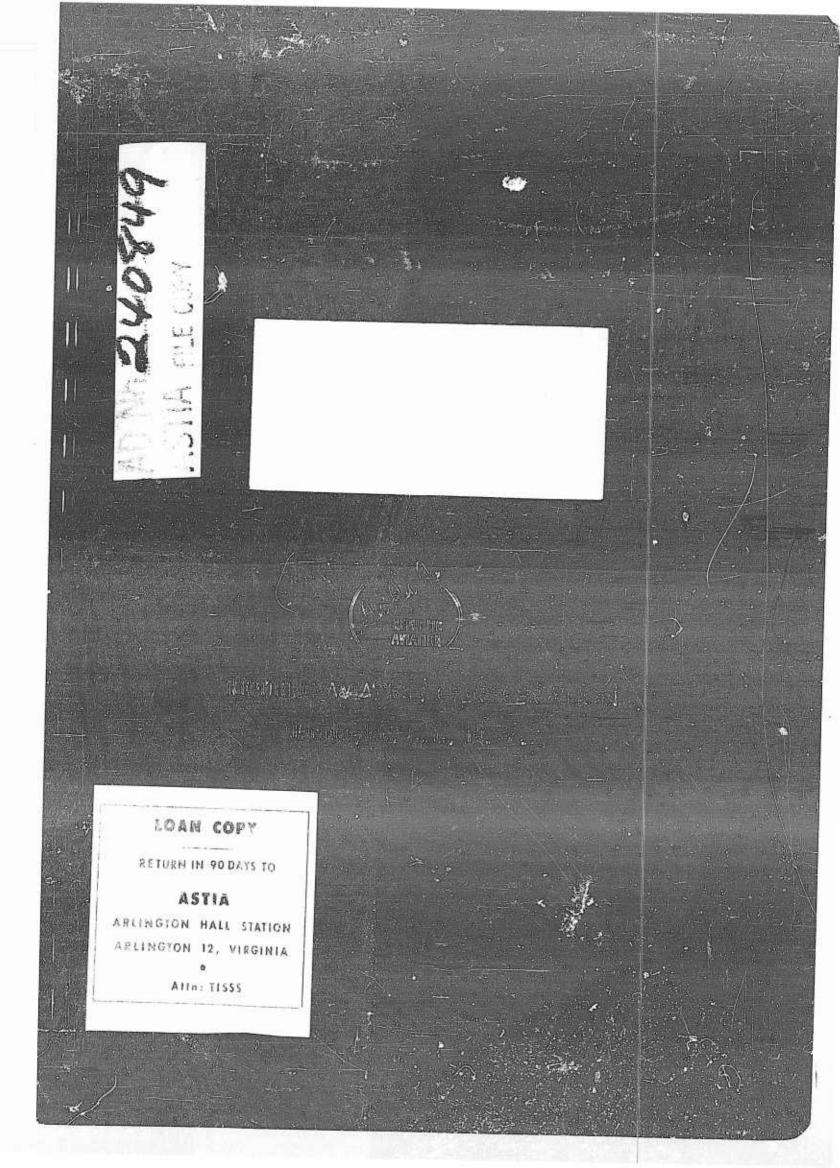
ARMED SERVICES TECHNICAL INFORMATION AGENCY
ARLINGTON HALL STATION
ARLINGTON 12, VIRGINIA



UNCLASSIFIED

NOTICE: When government or other drawings, specifications or other data are used for any purpose other than in connection with a definitely related government procurement operation, the U. S. Government thereby incurs no responsibility, nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the nolder or any other person or corporation, or conveying any mights or permission to manufacture, use or sell any patented invention that may in any way be related thereto.

Best Available Copy



ch Commandia

U. S. Army Transportation Research Command Fort Eustis, Virginia

> Contract No. DA 44-177-TC-606 Project No. 9R38-01-017-24

THEORETICAL INVESTIGATION OF DUCTED PROPELLER AERODYNAMICS

by

Dr. Th. Theodorsen
Director of Scientific Research

Volume II

The Theodorsen

Republic Aviation Corporation
Farmingdale, Long Island, New York
August 10, 1960

"The findings and recommendations contained in this report are those of the contractor and do not necessarily reflect the views of the Chief of Transportation."

crd 3860



DISCLAIMER NOTICE

When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

* * *

ASTIA AVAILABILITY NOTICE

Qualified requestors may obtain copies of this report from

Armed Services Technical Information Agency
Arlington Hall Station
Arlington 12, Virginia

* * *

This report has been released to the Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C., for sale to the general public.

* * *

The information contained herein will not be used for advertising purposes.

* * *

The publication of this report does not constitute approval by USATRECOM of the findings and conclusions contained herein. It is published only for the exchange and stimulation of ideas.

SECTION II

REVIEW AND ANALYSIS OF EXPERIMENTAL INVESTIGATIONS ON DUCTED FANS

TABLE OF CONTENTS

| | | • | Page |
|------|--------------------|--|----------------------|
| ı. | INTRODUCTION | | 74 |
| II. | ANALYTIC RELATIONS | | 76 |
| | Α. | Dimensionless Representation of Experimental Data | |
| | В. | Classification According to Specific Speed and Specific Diameter | 77 |
| | C. | Effects of Viscosity and Compressibility | 78 |
| | D. | Relations Derived From Momentum Theorem | 79 |
| *. | 88 | Forces Power Axial Flow Efficiency | 79 81 84 86 |
| III. | EXPERIM | ENTAL DATA | 88 |
| | A. | List of Experiments Reviewed in Detail, Order of Presentation | 88 |
| | В. | Experimental Results, Discussion and Specific Deductions | 90 |
| | | Summary Plots Static Performance Data Axial Performance Data Non-Axial Performance Data | 90 92 95 99 |
| | | Effect of Flow Separation on Performance | 101 |

SECTION II

TABLE OF CONTENTS (Cont'd.)

| | | Page |
|------|--|------|
| III. | EXPERIMENTAL DATA | 88 |
| | B. Experimental Results, Discussion and Specific Deductions | 90 |
| | 6. Moment Characteristics | 106 |
| | 7. Lift Characteristics of Shroud and Propeller at Small Angle of Attack | 108 |
| | 8. Effect of Tip Clearance | 109 |
| | 9. Contra-rotating Propeller | 110 |
| | 10. Viscosity and Compressibility Effects | 111 |
| | C. Special Configurations | 112 |
| | 1. Fan in Wing | 112 |
| | 2. Ground Proximity Effects | 113 |
| IV. | CONCLUSION | 116 |
| v. | LIST OF SYMBOLS | 118 |
| VI. | LIST OF REFERENCES | 125 |
| VII. | FIGURES | 136 |
| | | |

I. INTRODUCTION

Theoretical methods used in treating the ducted fan problem are dealt with in the previous part of this report where also specific extensions to the theory are given. Theoretical methods are indispensible for a rational treatment of the subject. To verify theoretical solutions, to determine deviations due to the real properties of the medium, and to treat configurations too complicated for analysis, experiments are needed.

A comprehensive survey of published experimental work on ducted fan configurations is made in the following. This survey gives an outline of some analytic relations used to document and analyze experimental result. It then selects a number of experimental papers which make significant and consistent contributions and analyzes their results in detail. Major subsections are dealing with the performance in the static or hovering case of the configuration, with performance fields for the case where the fan is moving in axial direction and with the analysis of the performance in non-axial flow which is the flow encountered by a configuration making a transition from hovering to forward flight. Specific observations derived from the analysis and concerning, e.g. the distribution of rolling and pitching moments for a

shrouded and unshrouded propeller, evidence and recognition of flow separation on the shroud, etc. follow. Special arrangements of fans in wing, multiple fan arrangements, and ground proximity effects are reviewed in the following section. The concluding part of this report briefly reviews the general considerations that go into the design of ducted fan systems.

II. ANALYTIC RELATIONS

If A. Dimensionless Revesseration of Experimental Data

In the theory of model., rules are derived to present the performance of a system from observious made on a different scale system (model). In application to fluid flow this common practice to express the performance of a turbo machine by characteristic dimensionless quantities (coefficients) which are obtained through combinations of observed physical quantities and which in turn can be used to predict the performance of geometrically similar machines of arbitrary size.

Without going further into detail reference is made to the list of symbols where all the coefficients used are isted and d fined.

Attention is called to the fact that two systems of coefficients are used, distinguished by the symbol K and C respectively. The K-coefficients are based on the r.p.m. and the diameter of the propeller, and the C-coefficients are based on the flight velocity and the propeller disc area. These systems are used generally in the literature, however variations occur with respect to constants (radius instead of diameter, factor T, etc.). The K-coefficient representation is used for the majority of the experimental results shown in this report.

Inspection of the coefficients listed and of the data given in Section III will demonstrate their usefulness in describing the performance of existing machines by dimensionless quantities independent of scale and measuring system.

II B. Classification According to Specific Speed and Specific Diameter

A different situation exists when the problem is to either classify a given machine with respect to other machines of the same kind (but not geometrically similar) or to design a new machine for a given task. Such classification or orientation for a new design can be obtained by forming a dimensionless or specific speed n_S and a dimensionless or specific diameter d_S using the essential physical dimensions of the machine as mass flow density and energy imparted to unit mass.

For application to ducted fans we define

$$n_{\mathcal{G}} = n\left(\rho, v_{e}, v_{o}, d\right) = \frac{\sqrt{K_{T}}}{J^{2}} \sqrt{8\pi}$$

and

$$d_S = d(\rho, v_e, v_o, d) = \frac{J}{\sqrt{K_T}} \sqrt{\frac{\pi}{8}}$$

(The constants are carried here to conform with other sources and facilitate comparison).

If these specific values are evaluated with the values obtained at or near best performance (highest efficiency) for various machines

and entered in a logarithmic plot n_S vs. d_S they are found to group closely to one universal curve. A plot of this kind is discussed in the subsequent paragraph III B 1 where it serves to give a summary representation of the axial performance of a large number of different ducted fan systems.

II C. Effect of Viscosity and Compressibility

The simple similarity law which is the basis of the derivation of performance coefficients (II A), assumes a perfect fluid medium. In reality the medium, be it air or water, is viscous as well as compressible. The similarity parameters governing viscosity and compressibility are the Reynolds number and the Mach-number.

Since it is usually not possible to carry out model tests satisfying the correct similarity conditions it is correct practice to describe deviations observed under the simplified similarity assumptions as functions of Reynolds number or Mach-number. Those deviations are commonly called scale effects and compressibility effects. A recent survey on ducted fans (ref. 62) observes that little is known on such effects with respect to ducted fans. This is literally true and due to a general lack of systematic tests on the subject. Nevertheless these effects have been thoroughly explored by developers of propellers as well as axial compressors. Since the ducted fan is very closely related to propellers

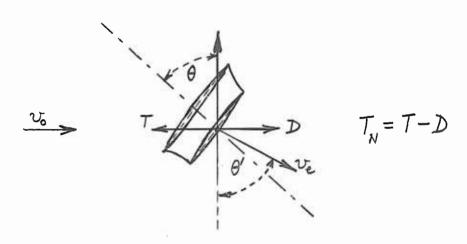
and axial flow compressors, it is desirable to compare scale and compressibility effects with recourse to such data.

An example of experimental determination of scale and compressibility effects on axial compressors is given in Section III B 10.

II D. Relations Derived From Momentum Theorem

For the analysis of the experimental data the following relations are derived for the forces and the power of a propeller system.

II D 1. Forces



A coordinate system is considered which is fixed on the propeller.

The mass flow is

$$\dot{M}_{s} = \rho A_{e} v_{e} \cos \left(\theta - \theta \right) \tag{1}$$

The lift is

$$L = M_{s} v_{e} \cos \theta' = \rho A_{e} v_{e}^{2} \cos (\theta' - \theta) \cos \theta'$$
 (2)

The net horizontal force is

$$T_{N} = \dot{N}_{S} \left(v_{e} \sin \theta - v_{o} \right) - c_{b} \frac{1}{2} \rho v_{o}^{2} S \tag{3}$$

where the last term represents the aerodynamic drag of the system and $S = k A_e$ is the reference area.

For steady flight with velocity $\,\mathcal{U}_{\!o}\,$ the net horizontal force is

$$T_N = 0$$

i.e.,

$$\dot{M}_{s}v_{e}\sin\theta' = \dot{M}_{s}v_{o} + C_{D}\frac{k}{2}\rho v_{o}^{2}A_{e}$$
 (4)

and the lift should be

$$L = W - C_L \frac{k}{2} \rho v_o^2 A_e \tag{5}$$

where W is the weight and the last term is the aerodynamic lift of the system.

Making use of Eqs. (2) & (5) and (1) & (4) we find respectively

$$v_{e}^{2}\cos\theta'\cos(\theta'-\theta) = \frac{W}{\rho A_{e}} - c_{L}\frac{k}{2}v_{o}^{2}$$

$$v_{e}^{2}\sin\theta'\cos(\theta'-\theta) = v_{e}v_{o}\cos(\theta'-\theta) + c_{D}\frac{k}{2}v_{o}^{2}$$
(6)

This is a system of two equations with two unknowns \mathcal{C}_{ϵ} & θ . Thus, for any given value of the velocity \mathcal{C}_{δ} we can find \mathcal{C}_{ϵ} & θ provided that we know the aerodynamic coefficients \mathcal{C}_{δ} & \mathcal{C}_{ϵ} and a relationship between the angles θ & θ .

Assuming $\theta = \theta$ the system of Eqs. (6) becomes:

$$v_e^2 \cos \theta = \frac{W}{\rho A_e} - C_L \frac{k}{2} v_o^2$$

$$v_e^2 \sin \theta = v_e v_o + C_D \frac{k}{2} v_o^2$$
(7)

A graphical solution of this system is readily obtained after squaring and adding the two equations so that the angle θ will be eliminated. Then we solve for θ from any of the two equations.

II D 2. Power

The ideal power of the propeller is given by the change in the kinetic energy of the mass flow

$$P = M_s \left(\frac{v_e^2}{2} - \frac{v_o^2}{2}\right) = \rho A_e \frac{v_e^3}{2} \cos(\theta - \theta) \left[1 - \left(\frac{v_o}{v_e}\right)^2\right]$$
(8)

Thus, for a given steady state and aerodynamic characteristics of the system, we can find:

the exit velocity v_e . the angle of inclination θ and the ideal power of the propeller \mathcal{P} .

From Eq. (8), it is obvious that the power of the propeller is a function of both the exit velocity v_{e} and the ratio v_{e} .

Since for steady state the net horizontal force should be zero, the thrust component of the propeller counterbalances the total drag, and the inclination of the propeller axis θ is found from Eq. (4).

If two separate propellers are used, one in the horizontal and the other in the vertical direction, then the power required is given by

$$P = P_1 + P_2$$

where:

(vertical)
$$P_{1} = M_{s_{1}} \left(\frac{v_{e_{1}}^{2} - v_{o}^{2}}{2} \right)$$
(horizontal)
$$P_{2} = M_{s_{2}} \left(\frac{v_{e_{2}}^{2} - v_{o}^{2}}{2} \right)$$

For

$$\dot{M}_{SI} = \dot{M}_{S} \qquad v_{eI} = v_{e} \cos \theta'$$

$$\dot{M}_{SZ} = \dot{M}_{S} \frac{v_{eZ}}{v_{eZ} - v_{o}} \qquad v_{eZ} = v_{e} \sin \theta' \qquad (10)$$

we have that the net thrust and lift are the same, i.e.,

$$L = L_1 + L_2 = M_{51} v_{e_1} + 0 = M_5 v_e \cos \theta'$$
 (2a)

$$T_{N} = T_{1} + T_{2} = -\dot{M}_{s} p_{0} + \dot{M}_{s2} (v_{e2} - v_{0}) - c_{D} \frac{k}{2} p v_{0}^{2} A_{e}$$

$$= M_s \left(v_{e2} - v_o \right) - C_D \frac{k}{2} \rho v_o^2 A e$$
(3a)

Solving for A_{e_1} and A_{e_2} from Eqs. (1) and (10), we find ($\theta_1' = 0$) $\theta_2' = \theta_2 = 90^\circ$)

$$\dot{M}_{s} = \rho A_{e_{1}} v_{e_{1}} \cos \theta_{1} \qquad A_{e_{1}} = A_{e} \frac{\cos(\theta - \theta)}{\cos \theta \cos \theta_{1}}$$
 (11)

$$\dot{M}_{s} = \rho A_{e_{2}} v_{e_{2}} \frac{v_{e_{2}} - v_{o}}{v_{e_{2}}} \qquad A_{e_{2}} = A_{e} \frac{\cos(\theta' - \theta)}{\sin \theta' - \frac{v_{o}}{v_{e}}}$$
(12)

Making use of Eqs. (9), (10), (11) and (12), the required power becomes

$$P = P_1 + P_2 = M_{s_1} \frac{v_{e_1}^2 - v_o^2}{2} + M_{s_2} \frac{v_{e_2}^2 - v_o^2}{2}$$

$$= \frac{M_s}{2} \left[v_{e_1}^2 - v_o^2 + \frac{v_{e_2}}{v_{e_2} - v_o} (v_{e_2}^2 - v_o^2) \right]$$

or

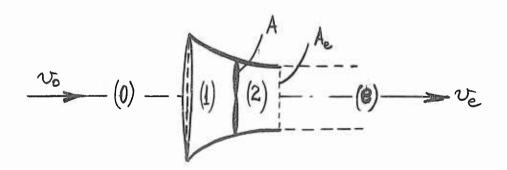
$$P = \frac{M_s}{2} \left[v_{e_1}^2 + v_{e_2}^2 - v_o^2 + v_{e_2} v_o \right]$$

$$= \frac{M_s}{2} \left(v_e^2 - v_o^2 \right) + \frac{M_s}{2} v_{e_2} v_o$$
(13)

Thus from Eqs. (8) and (13), it is obvious that if we use two separate propulsion units to produce the same velocity and momentum in the vertical and horizontal direction, then more ideal power is required than that of a single properly inclined propeller unit.

II D 3. Axial Flow

For the experimental case of axial flow through a ducted propeller supported at the test section of a wind tunnel we have the following:



From Bernoulli's equation at the regions (0) & (1) and (2) & (e), we have

$$\begin{aligned}
& \int_{0}^{2} + \frac{1}{2} \rho v_{0}^{2} = \int_{1}^{2} + \frac{1}{2} \rho v_{1}^{2} \\
& \int_{0}^{2} + \frac{1}{2} \rho v_{0}^{2} = \int_{2}^{2} + \frac{1}{2} \rho v_{2}^{2}
\end{aligned} \tag{14}$$

For the same static pressure at (0) and (e), we have $\int_0^2 \int_e^2$, and from continuity $v_1 = v_2$.

Thus, subtracting Eqs. (14) and multiplying by A we get:

$$T_{p} = A(P_{2} - P_{1}) = \frac{1}{2} \rho A_{e} v_{e}^{2} \frac{A}{A_{e}} \left[-\left(\frac{v_{o}}{v_{e}}\right)^{2} \right]$$
(15)

which is the propeller thrust $\int_{\mathcal{P}}$.

The net thrust is equal to:

$$T_{N} = \rho A_{e} v_{e} \left(v_{e} - v_{o}\right) - c_{D} \frac{k}{2} \rho v_{o}^{2} A_{e}$$
or
$$T_{N} = \rho A_{e} v_{e}^{2} \left[1 - \frac{v_{o}}{v_{e}} - \frac{k}{2} c_{D} \left(\frac{v_{o}}{v_{e}}\right)^{2}\right]$$
(16)

and is equal to the force measured on the balance of the wind tunnel where:

$$T_{N} = T_{p} + T_{s}$$

$$T_{s} \text{ is the shroud thrust.}$$
(17)

Making use of Eqs. (15), (16) and (17) we find

$$T_{s} = \rho A_{e} v_{e}^{2} \left\{ 1 - \frac{v_{o}}{v_{e}} - \frac{k}{2} C_{D} \left(\frac{v_{o}}{v_{e}} \right)^{2} - \frac{1}{2} \frac{A}{A_{e}} \left[1 - \left(\frac{v_{o}}{v_{e}} \right)^{2} \right] \right\}$$
(18)

Dividing Eqs. (15) and (18) by Eq. (16). we find respectively,

$$\frac{T_{p}}{T_{N}} = \frac{\frac{1}{2} \frac{A}{A_{e}} \left[1 - \left(\frac{v_{o}}{v_{e}} \right)^{2} \right]}{1 - \frac{v_{o}}{v_{e}} - \frac{k}{2} C_{D} \left(\frac{v_{o}}{v_{e}} \right)^{2}}$$
(19)

and

$$\frac{T_{s}}{T_{N}} = 1 - \frac{\frac{1}{2} \frac{A}{A_{e}} \left[1 - \left(\frac{v_{o}}{v_{e}} \right)^{2} \right]}{1 - \frac{v_{o}}{v_{e}} - \frac{k}{2} C_{D} \left(\frac{v_{o}}{v_{e}} \right)^{2}}$$
(20)

II D 4. Efficiency

The efficiency of a propeller system is defined as the ratio of the ideal power to the actual power used:

Making use of Eq. (8), the above equation becomes

$$\gamma = \frac{\rho A_e v_e^3 \cos(\theta' - \theta) \left[! - \left(\frac{v_o}{v_e} \right)^2 \right]}{2 P_{\text{actual}}}$$
(22)

For $\psi = 0$ then $\theta = \theta$ and the efficiency η becomes

$$\gamma_{ST} = \frac{\rho A_e v_e^{*3}}{2P_{\text{actual}}^*}$$
(23)

where v_e^* is the exit velocity and P_{actual}^* is the actual power for the case of $v_o = 0$. This efficiency γ_{ST} is sometimes called figure of merit.

III. EXPERIMENTAL DATA

III A. List of Experiments Reviewed in Detail, Order of Presentation

Experiments reduced and analyzed in detail, are listed below.

The exact quote is given in the list of references.

| | Fig. No. | Reference |
|---|----------|-----------|
| Hoehne, V. O. and Wattson, R. K. University of Wichita (7) Reports | 8-49 | 17-23 |
| Gill, W. J. Hiller Aircraft Corporation | 50-108 | 7 |
| Grose, R. M. United Aircraft Corporation | 109-114 | 12 |
| Platt, R. J. NACA | 115-121 | 60 |
| Krüger, W. AVA Goettingen, Germany | 122-130 | 31 |
| Van Manen, J. D. Wageningen, Holland | 131-138 | 80, 81 |
| Allen, H. J. and Rogallo, F. M. Stanford University | 139-141 | 1 |
| Moser, H. H., Livingston, C. L., MIT | 142-151 | 52 |
| Taylor, R. T. NACA | 152-154 | 74 |
| McLemore, H. C., and Cannon, M. D. NACA | 155-167 | 47 |

The above list shows those experimental reports which were

found to contribute significantly either by dealing with a configuration correlated to theoretically determined shapes or by investigating a fairly wide range of performance of a specific configuration, or by illustrating certain characteristics of specific interest. Inclusion in this list does not indicate that the results obtained were particularly outstanding.

The experimental results were reduced uniformly using the quantities and coefficients listed in the list of symbols. The following order is used: The data curves from one investigation are arranged in a group and within the various groups the sequence is: configuration (sketch and designation), static performance data, axial performance data, non-axial performance data and additional related data, e.g., velocity distributions, etc.

The static performance representation requires only two plots per configuration namely, static efficiency γ_{ST} vs. thrust coefficient K_T and the thrust division T_S/T vs. K_T . Various blade angles are noted along the curves.

The axial performance is represented in the performance field K_T vs. advance ratio J with the blade angle β as parameter and curves of constant propulsive efficiency η_P shown in the same graph. The

thrust division is shown as T_S/T vs. J. Thus, again two plots describe the axial performance.

All non-axial performance data are shown vs. the angle of tilt θ . The performance is described in a set of graphs showing in coefficient form the resultant force R and its components lift L and drag D. This is followed by a graph of dimensionless fan power K_p and graphs showing the shroud lift K_{LS} and drag K_{DS} and the division of lift K_{LS} . Pitching and rolling moments of the configuration are shown as the moment arms e_m and e_k respectively, made dimensionless with the fan diameter and defined as the arm on which the resultant R acts to produce the observed moment. Thus, a total of eight graphs is used to describe non-axial performance.

In the following sections it is attempted to point out characteristic features of ducted fan systems. To keep the text within reasonable proportions the discussions are based on and limited to a few selected examples.

III B. Experimental Results, Discussion and Specific Deductions

III B 1. Summary Plots

Figures 6 and 7 show summaries of static performance of ducted fans. Static efficiency η_{ST} is plotted versus exit area loading

in figure 6 and versus thrust coefficient $K_{\rm T}$ in figure 7. Most of the data fall within the 80% \pm 8% band.

A static summary plot can also be obtained by entering corresponding values of thrust and power into a plot of T/P versus T/A_e as discussed in II D 3a. This has been done in figures 2 and 3.

A summary of axial performance of ducted fans is shown in figure 5. Corresponding values of specific speed n_S and specific diameter d_S taken for optimum performance are entered in a logarithmic plot. These specific values were derived and defined in II B. It is seen that all values group closely to one universal curve. It may be mentioned that this curve is universal for all kind of turbomachinery and may be extended downward through propellers, axial compressors, Kaplan turbines, radial compressors, to Pelton turbines (ref. 5).

Figure 5 can also serve for selecting the basic dimensions and speed of a new design. Determining from prescribed design data d_S and selecting a n_S from the universal curve, or vice-versa, assures a configuration with which high propulsive efficiency can be obtained.

III B 2. Static Performance Data

Static performance data are contained in figures 9 to 12, 52 to 58, 110, 111, 116 to 121, 123 to 125, 132 to 135, 143 and 144, and for a free propeller in figure 155.

As an example figures 9 and 11 shall be discussed. The curves shown were produced by varying the inlet stator blade angles. (Similar curves can be produced by varying rotor blade angles, figures 10 and 12. Highest efficiency is associated with a certain thrust, i.e., the fan operates with best efficiency at a mass flow corresponding to this thrust. The bellmouth inlet shows higher efficiency than the high speed inlet because it is able to carry more thrust (fig. 11, 43% against 30% of total). The loss of thrust on the sharp lipped high speed inlet is due to flow separation and the attendant loss of suction areas on this inlet. Flow separation on sharp lipped inlets can be demonstrated experimentally. In references (7) and (12), it is demonstrated through pictures of tufts and oilflow patterns. Figures 52 to 57 and 110 & 111 show the static data for these references.

It is possible however, for a relatively sharp lipped shroud to carry a sizeable portion of the total thrust. In figures 115 to 121, data from reference 60 have been plotted. Note that in figure 116, efficiency is high for all configurations. The accompanying shroud thrust data of

figure 119 show that about 60% of the total thrust is carried by the shroud. Shroud thrust data presented in the figures were obtained from pressure measurements. This thrust, therefore, represents an upper limit which probably could not be attained in practice, for it does not include skin-friction drag and support-strut drag and interference. Check points taken with strain gages indicated a shroud thrust about 10% lower than the pressure measurements. Total thrust therefore, is probably about 6% too high. Corresponding efficiencies should be about 9% lower than indicated since efficiency is related to the 3/2 power of thrust for the same power. A typical shroud pressure distribution is shown in figure 117. Note the high negative peak at the inlet, and the slight discontinuities caused by the propellers. It is seen also that the static pressure for this short shroud is restored to ambient pressure at the exit, indicating no contraction or expansion in the wake. Velocity distributions presented in figure 118 show that the propeller renders more uniform the initial non-uniform distribution induced by the shroud.

Fan blade stall can, severely hamper static performance of a system. This is demonstrated, e.g., in figure 123. Static efficiency falls off rapidly at a certain blade angle ($\beta = 50^{\circ}$ for the uppermost curve) and for increasing blade angles the curves fold under due to the concurrent

loss of thrust. Shroud thrust under those conditions may considerably exceed 50% (figure 128, J=0) which of course is due to diffusion behind the propeller.

That shroud thrust can increase above 50% of total thrust with a diffusing shroud is also seen in figure 154 where experimental results are compared with the theoretical momentum relation $T_{\rm S}/T=1-(1/2)\,A/A_{\rm e}.$

Figure 123 also demonstrates the effect of an exit stator which for this case of a fairly highly loaded fan is seen to improve static efficiency by more than 10%.

That a correctly designed shroud induces additional velocities at the propeller is also evident in the same figure 123. The unshrouded propeller begins to stall at a blade angle of $\beta = 25^{\circ}$ while this same propeller with a shroud does not reach best efficiency before $\beta = 35^{\circ}$ to 40° .

The water tests of van Manen (refs. 80 and 81) figures 132 to 135, appear to exhibit little evidence of shroud separation with the exception of a model consisting of a propeller in an axial circular cylinder. The relatively good performance of the other configurations is due to the use of a design procedure similar to that outlined by Küchemann and

Weber in reference 33 and the choice of slopes which induces fairly high velocities on the inside. It is obvious that the axial circular cylinder is the correct design for only the trivial case of infinitesimally small propeller loading in axial flow, and therefore, is to be expected not to demonstrate good efficiency at static conditions.

In general, it can be observed that high efficiencies can be obtained with free propellers as well as with ducted propellers provided the ducted propeller is correctly designed as a unit.

III B 3. Axial Performance

Axial performance data are contained in figures 13 to 20, 59, 60, 112, to 114, 126 to 130, 136 to 138, 140 to 141.

The performance field is used throughout to describe axial performance. This is a plot of corresponding values of thrust coefficient and advance ratio. Fan blade angle β (occasionally stator blade angle β_v) is parameter to the K_T vs. J curves. Points of constant propulsive efficiency γ_P are connected and form (generally closed) curves which are labelled with the respective propulsive efficiency value. Supplementing the performance plots are plots of thrust division T_S/T vs. advance ratio J with β again as parameter.

Figure 19 and its corresponding plot of shroud thrust, Fig. 20,

shall serve as an example to illustrate the kind of information that can be extracted from such plots. Thrust is seen to vary directly with blade angle and inversely with advance ratio. Maximum efficiency occurs at a particular blade angle and advance ratio. An area of good efficiency is found in the middle of the field allowing for some variation in β and β and β without severe loss of efficiency. From figure 20 it appears that the point where shroud thrust becomes zero corresponds closely to operation near best efficiency for a given value of blade angle β . This situation was found consistently in all the data examined figures 13, 14; 15, 16; 17, 18; 112, 113, with the exception of the data of reference 31 figures 127 and 128.

and 22 with the performance field of a bellmouth shroud, figure 17 and 18 shows typical differences. The most pronounced difference is an increase of the slope of the K_T vs. J curves caused by the better performance of the bellmouth shroud at low J and its higher drag at high advance ratios. This high drag is also the reason why the bellmouth shroud shows lower peak efficiency. In contrast, the high speed shroud may exhibit loss in thrust at low advance ratios (unstable characteristic, fig. 19) due to shroud separation or blade stall or a combination of both. Blade stall may be quite severe particularly if the fan is an aerodynamically highly loaded efficient limit design, fig. 127, $\beta = 65^{\circ}$.

Pressure distributions on a shroud for various advance ratios are shown in figure 129. At near static conditions (low J), high suction pressures are observed which quickly decrease with increasing advance ratio, while the pressure distribution approaches the distribution on the shroud without a propeller. Accompanying velocity surveys in the inlet, figure 130 show the same trend. It is interesting to note that changes in the normalized velocity distribution with advance ratio are small. The low values near the hub at high advance ratio are not typical but are due to a thick boundary layer developing over the long forebody, see fig. 122.

Performance fields of a free propeller and this same propeller in a duct from reference 7 are shown in figures 59 and 60. The performance fields shown are fragmentary because the tests were not extended far enough to include optimum performance. The effect of the duct to shift the area of best performance toward higher advance ratios can, nevertheless, be seen from a comparison of the figures. Also apparent are the higher thrust and the lower efficiency obtained with the shrouded configuration at low advance ratios.

Early tests by Allen and Rogallo, ref. 1, figures 139 to 141, show that little advantage is to be gained with the addition of a shroud to a lightly loaded propeller ($T/A \approx 3 \text{ lb/ft}^2$). Figure 140 shows that

shroud thrust is a very low fraction of the total thrust, and a comparison of figures 140 and 141 will show that the unshrouded propeller operated at higher efficiency than the shrouded propeller. The tip clearance for these tests was very large (.0185 of propeller radius) and the blade tips were well rounded. It is evident that the deleterious effects of tip clearance as shown in figure 170, are responsible for the low shroud thrust.

When the propeller is designed to operate within a shroud as is the case with reference 31, operation of this propeller unshrouded should result in a lower efficiency. A comparison of figures 126 and 127 shows that the shrouded propeller operated more efficiently than the same propeller without a shroud.

The water tests of van Manen (references 80 and 81) showed that at sizeable forward speed, higher efficiency was obtained with a straight circular cylinder of one diameter length than with shrouds having airfoil profile cross sections. (Figure 136 compared to figures 137 and 138. The reason is probably that the straight cylinder has only a small separated region near its leading edge when operating under light propeller loading ($K_T=0.13$) and that the flow is able to reattach before entering the propeller plane due to the considerable length of the shroud. Thus, this shroud acts essentially as an end plating device

insuring full loading over the blade span. In contrast the bellmouth shrouds probably incur separation on the outside and possibly cavitation and as a consequence, large drag. The distinct kink in the $\rm K_T$ vs. J curves of these shrouds (figs. 137 and 138) appears to confirm this deduction.

III B 4. Non-axial Performance

Non-axial performance data are contained in figures 21 to 49, 61 to 108, 145 to 148 and for the free propeller in figures 156 to 167.

The lift and drag forces on the shroud and the ratio of shroud lift to total lift are shown in figures 25 to 27, 33 and 34, 40 and 41, 47 and 48, 74 to 76, 86 to 88, 95 to 99, 104 to 106.

As an example, the lift division for a bellmouth and a high speed shroud figures 27 and 33 may be discussed. Shroud lift is seen to increase with advance ratio and the increase is relatively larger for the high speed inlet. The sudden fall-off of the shroud lift (figure 33, J=0.7) is probably due to separation on the high speed shroud and is seen also in the total lift graph (figure 30).

It is interesting to note that in forward flight the shroud lift increases relative to that for static conditions. This is to be expected

in the case of the high speed inlets (see fig. 33) for unseparated flow, however, this characteristic is even demonstrated by the bellmouth shroud which when operated as ring wing without a propeller, has very poor lift/drag ratio (ref. 7).

Test results for a rigid unshrouded propeller are presented in figures 155 to 167. The propeller was operated as a thrust generator throughout the range of forward speed and angle of tilt. The values of advance ratio employed varied from 0.2 to 6.2 which correspond to ratios of forward speed to tip speed from \sim 0.06 to \sim 2.0. The lowest tilt angle tested was 7.5°.

Increasing J has an unloading effect at high tilt angles and the opposite effect at low tilt angles, the blade loading becoming more asymmetric with increasing J and decreasing tilt. The above points may be illustrated by reference to figures 156, 157, 158, 159 and 160 where the forces and power input are shown versus tilt angle for β . 75R = 30°. Additional data for β . 75R = 40° may be seen in figures 162, 163 and 164. The effects of asymmetric blade loading may be seen in the moment data. (Fig. 161 and 165) Note that:

- a. Rolling moment is about three times pitching moment.
- b. Increasing J displaces the resultant vector outward.

c. Variations with tilt angle become more erratic with increasing blade angle as J increases.

The causes of these effects may be seen in figure 168 where the blade angle at .75 radius for zero net loading is expressed as a function of J and tilt angle. For a constant blade angle and J < 2.36, decreasing J or tilt angle has the tendency to increase the net section angle of attack at different rates, thus unevenly loading the blades. At values of J approaching 2.36, the retreating blade undergoes large changes in section angle of attack which is responsible for the erratic variations in the moment data in this range.

III B 5. Effect of Flow Separation on Performance

Flow separation on ducted fan configurations occurs quite frequently and has usually a marked effect on performance. Separation on the duct ahead of the fan can also have a compounding or triggering effect because it may cause blade stall with violent changes in performance. Some examples of experimental evidence of flow separation are therefore discussed in this paragraph.

Inspection of fig. 81 shows that as tilt angle is decreased the flow on the inside of the forward part of the bellmouth shroud separates. The separation increases as the tilt is decreased until finally at $\theta = 20^{\circ}$.

very little flow passes through the forward part of the shroud. This observed exit distribution is the result of inflow disturbances and whatever changes have been added by the propeller. It is reasonable to assume therefore that the inflow distribution is similar. A propeller operating in such a flow would experience higher section angles of attack during the forward traverse of the blade than the rear traverse, resulting in positive (nose up) propeller moments. This, in fact, is seen in fig. 79. At low values of tilt angle, the propeller moments are positive and the total moment is also positive (fig. 78). As the flow asymmetry is decreased, i.e., the tilt is increased, the propeller moment becomes negative while total moment remains positive. Reference to moment data for this propeller without the bellmouth shroud (fig. 65) shows that at low tilt angles, the propeller moment is also positive and of the same order of magnitude. This and the fact presented earlier that the mean wake direction at low tilt angles deviates rearward from the propeller axis strongly suggests that the flow through the Hiller bellmouth shroud resembles that through a free propeller as a result of flow separation from the shroud. It can be seen from the velocity distributions in fig. 81 that the separation becomes progressively worse as the tilt decreases.

Reference to data for a more highly loaded shrouded propeller

(ref. 17-23) reveals a different characteristic. As an example, figs. 36 to 40 may be consulted. It is seen that together with the variations described for reference 7 (fig. 72, 73 and 77), there are now sharp decreases in resultant lift and drag followed by increase in power at a tilt of less than 30° and J=1.4. It can be inferred that the sharp decreases in lift, drag and resultant at low tilts are the result of the compounded effects of a separation at the forward shroud lip and blade stall.

It must be realized that shroud separation and fan stall, or more precisely, cyclical fan blade stall in the forward section of the duct, are closely linked. It is therefore not always possible to distinguish clearly the two effects if only summary measurements of forces or exit velocity distributions are available. Qualitatively, however, the situation can be described. Incipient shroud separation first increases the aerodynamic loading on those parts of the fan blade which traverse the separated regions due to the reduced velocity in those regions. Depending on how closely the blade was originally operating near its maximum lift coefficient and on the size of the separated region this may lead to blade stall. As soon as blade stall occurs and spreads spanwise over a sizeable portion of the blade the shroud separation region will increase and take up even larger parts

of the cross section. Thus it is evident that mutually compounding effects are an essential feature of the whole process.

Static separation phenomena have been described by Platt, ref. 60, and Hubbard, in ref. 26, as function of propeller rotational speed. Platt has noted that at low rotational speeds the flow separates from the shroud at the leading edge. Operation in this condition is rough and accompanied by much noise; as the propeller speed is increased, the flow suddenly attaches at the inlet resulting in smooth, quiet operation with much higher shroud thrust. This is probably due to transition occurring in the shroud boundary layer as a consequence of increasing Reynolds number and the turbulent boundary layer being able to remain attached in the adverse pressure gradient. Comparison of shroud pressure distributions for the unseparated and separated flow conditions shows that they differ only in that the low-pressure region at the nose is lost in the separated condition. The shroud thrust in the separated flow condition is then only about .25 total thrust.

The report of Hubbard, (ref. 26) on sound pressures is consistent with the foregoing result of Platt, (ref. 60) in that higher sound levels were observed when the flow over the shroud inlet was separated. For these static tests which were conducted outdoors, wind direction

was critical in establishing the flow in the shroud. Cross winds and tail winds generally caused a separation of the flow on parts of the shroud surface, and head winds generally assisted in establishing unseparated flow. Flow conditions in this case were observed by means of tufts located around the periphery of the shroud on the inside surface near the leading edge.

The effect of shroud inlet radius is illustrated in fig. 153.

Increasing lip radius is seen to improve the thrust performance. It must be pointed out that a simple radius is not the correct shape for an inlet and will not result in a highly effective minimum-length inlet.

Such an inlet should be designed to avoid or minimize adverse pressure gradients. A large amount of literature exists on this subject and ref. 84 is mentioned as an example.

Shroud separation caused by small inlet radii is often the predominant factor in static performance tests, figs. 52 through 57.

Although obvious, fig. 151 (b), it is occasionally not recognized.

The picture is complicated when shroud separation affects the operation of the propeller and then may lead to contradictory results regarding required propeller pitch distribution ("washout" instead of "wash-in" at the blade tips) figs. 143 and 144.

In the axial case, increasing forward speed will of course always tend to reduce separation and at a certain forward speed even the most sharp lipped shrouds will have completely attached flow, resulting in good efficiency. See for example fig. 136 which shows good performance even for a thin-walled circular cylinder shroud provided the advance ratio is sufficiently high.

III B 6. Moment characteristics

Moment representation: Pitching moments are represented by the arm $\,e_m$ on which the resultant force R must act to produce the observed moment. Corresponding rolling moments are expressed by the arm $\,e_\ell$. The arms are made dimensionless by division with propeller diameter $\,d$.

A characteristic difference between the moments on a ducted fan and on a free propeller can be seen comparing figs. 28, 42 and 49 with figs. 161 and 165. The pitching moments (e_m/d) of the three shrouded configurations (figs. 28, 42, 49) are seen to vary with tilt angle approximately as a cosine function and to increase nearly linearly with forward speed; rolling moments are quite small. The opposite is true for a free propeller (figs. 161 and 165). Rolling moments are large and distinctly variable with advance ratio, while pitching moments are small and only slightly dependent upon forward speed.

The reasons are the following: on a free propeller rolling moments are caused by differences in section angle of attack of the advancing and retreating blades. Pitching moments on a free propeller are positive (nose-up). The addition of a shroud reduces the rolling moments of the configuration because the flow through the propeller is made more axial and differences felt by the advancing and retreating blades are reduced. The addition of a shroud increases the positive (nose-up) pitching moment of the configuration because due to high flow velocity over the leading part of the shroud, strong suction pressures are developed there. The propeller pitching moment is simultaneously reduced due to the shroud induced additional velocities (for the case of no separation) in the forward part of the propeller plane, but is overpowered by the duct moment.

The addition of stators to the shrouded configuration further affects the rolling moments. This latter effect is predominant in the experimental results shown in figs. 28, 42, 49. Further results on pitching moments substantiating the above remarks are contained in the material extracted from reference 7, figures 65, 70, 78, 79, 89, 90, 98, 107 and 108.

The effects of shroud separation on pitching moments have been discussed in detail in section III B 5. Flow separation can modify the

moments considerably. If the flow over the leading edge of a ducted propeller separates from the shroud, the low pressure on that part of the shroud is lost and consequently the positive duct pitching moment will be reduced. It has previously been shown that the flow over sharp lipped ducts is more prone to separation than the flow over gradually curving large bellmouth inlets. It is to be expected therefore that pitching mements for airfoil ducts will be lower than for bellmouth shrouds. This is illustrated in figs. 89 and 107. The moments shown in fig. 107 which are for an airfoil shape shroud are appreciably lower than those for the bellmouth shroud in fig. 89. Shroud lift for the airfoil duct is also appreciably lower, figs. 87 and 105.

III B 7. <u>Lift Characteristics of Shroud and Propeller at Low Angle of Attack.</u>

Figure 169 shows lift curve slope C_L versus power loading for two high speed shroud configurations. The first set of points taken from Hiller experiments (ref. 7) is for a small power loading of $K_P=0.019$. The points shown refer to the propeller alone, the shroud alone, and the combination of shroud and propeller. It is evident that the lift curve slope of the combination is the sum of the component slopes. Values for $C_L = 0$ are shown, however, $C_L = 0$ are shown, however, $C_L = 0$ are speciments.

The other high speed shroud configuration is that of ref. 12.

Data are presented for the isolated shroud, the propeller operating in the shroud, and the combination. Since isolated propeller lift was not available, additional data for a free propeller of similar geometry are presented. It is seen that the free propeller data and the data for the similar propeller operating in the shroud differ little. The sum of the latter data and the curve for the isolated shroud shows good agreement with the measured shrouded propeller lift at low power coefficients, again confirming the addition of lift curve slopes. Increasing deviation, however, occurs for increasing power loading, indicating increasing influence of the propeller flow upon the shroud flow. The tests showed constant lift curve slope up to the highest angle of attack investigated which was $0 \le 6.3^{\circ}$.

Bellmouth shroud configurations exhibit for increasing angle of attack first a regime where $\overline{C}_{L_{\infty}}=0$ followed by a regime of constant $C_{L_{\infty}}$. (see ref. 7).

III B 8. The Effect of Tip Clearance

The experiments of Hubbard, ref. 26, show a highly deleterious effect of tip clearance on shroud thrust, the thrust dropping to
13% of its extrapolated zero clearance value at a ratio of tip clearance
to propeller radius of only . 0435. fig. 170. (The tip clearance ratio

in this report is not clearly defined and it has been assumed to be the ratio of clearance to propeller radius). The power consumed in these tests was about 20% lower at a tip clearance ratio of .0435.

Tests by Hutton, ref. 27, show essentially the same trends. Measurements of axial velocity near the duct wall showed a decrease with an increase in tip clearance with an accompanying decrease in fan pressure rise of about 30% at a tip clearance of approximately 4% radius.

III B 9. Contra-rotating Propeller

Data for centra-rotating propellers at equal blade angle settings for both stages may be found in refs. 7 and 60. The former tests encompass a wide range of operating conditions while the latter were restricted to only static conditions. In the latter tests, however, individual measurements of propeller thrust and power and shroud thrust were made and these data are shown in figs. 119, 120 and 121. Sizeable differences in thrust and power exist between the two propeller components. No direct conclusions can be drawn from the latter tests as the number of blades differed in each component, and from the fromer tests because stage forces were not measured individually, nevertheless, certain general remarks may be made concerning contra-rotating propeller operation.

When equal blade angle settings are used for each component, the second

stage operates at higher section blade angles of attack and is likely to stall first. If lower but still equal settings are used, the first stage is not fully loaded and both stages can of necessity never work at peak efficiency simultaneously.

III B 10. Viscosity and Compressibility Effects

Scale and compressibility effects are important whenever it is attempted to use small scale model tests to predict the performance of a larger configuration. Although direct investigation of these effects on ducted fans is almost completely missing, it is nevertheless possible to use systematic studies in neighboring fields to predict those effects.

Figure 4 taken from reference 6, may serve as an example. Figure 4a shows results of systematic Reynolds number variations on an axial flow compressor stage (rotor plus stator). Reynolds number is defined here with tip velocity and blade chord and these two quantities together with number of blades z were varied. Multiplication of Re with $\lambda_{\rm P}$ refers the Reynolds number to the axial velocity through the compressor. The stage efficiency is seen to increase with Reynolds number. The kink in the $\gamma_{\rm stage}$ -envelope is probably due to the attainment of full turbulent attachment of the flow on the blade suction side.

The combined effect of Reynolds number and Mach number is shown in fig. 4b for another axial flow compressor stage. Mach number is defined as the ratio of tip velocity to local sound velocity. The same Reynolds number dependence is seen and in addition the sharp drop of efficiency when M=1 is approached.

Some effects of changes in velocity are also shown in figures 112 and 114 and, following the practice of the source, the data are labelled with Mach numbers. Because the effects are produced in the tests by velocity changes, they are however the combined effects of Mach and Reynolds number changes. It is believed that the Reynolds number effect is predominant in the results shown.

III C. Special Configurations

III C 1. Fan in Wing

A comparison of fan-in-wing data with any data of open or shrouded propellers is afforded by figures 145-148 where data from ref. 52 are represented in identically the same fashion as the non-axial data of the other investigations. Distinct differences can be seen. The lift no longer shows a gradual increase at moderate forward speeds and $\theta \approx 0$, but shows instead a rather steep increase effected undoubtedly by and characteristic of the wing.

Drag, on the other hand, varies almost linearly with velocity in the range of tilt angles shown demonstrating that the momentum drag of the fan is predominant (fig. 146). Pitching moments increase with forward speed and decrease with tilt angle. Power for the data presented (fig. 147) increased with forward speed, and decreased with tilt.

In addition, experiments with fan-in-wing arrangements (refs. 16 and 83) show moment behavior which is analogous to that of ducted fan configurations described in section III B 6, i.e., propeller moments are negative while total moments are highly positive with the effects of shroud separation being similar to those described earlier.

The results of hovering tests with a cascade-wing vertically rising airplane model are reported in ref. 45. Included also, are force tests to determine the effectiveness of simple cascades in redirecting the propeller thrust. These latter results may be seen in fig. 171.

III C 2. Ground Proximity Effects

Ground proximity effects have been observed to be either positive or negative, i.e., the lift produced by a system has been observed to increase or decrease in the proximity of the ground. This irregular and

apparently contradicting behavior can be understood, however, if the flow pattern and surfaces over which the flow moves are considered in detail.

Take first the free propeller, (helicopter). Upon approaching the ground, a stagnation point is formed on the ground and the flow spreads outward from that point, i.e., the streamlines become divergent at the propeller plane and consequently the pressure becomes higher there than without ground interference. Therefore, a higher propeller thrust or a positive ground effect is to be expected. This picture is slightly over-simplified but will serve for the present purpose of comparison. A more detailed analysis is given, e.g., in reference 30, where also the question of power and torque dependency are treated. Essentially the same flow pattern exists with the shrouded propeller except that now the increased pressure at the propeller plane produces reduced flow velocities over the duct inlet so propeller thrust increases while duct thrust decreases. Figure 151 illustrates this effect for a ducted fan and a fan-in-wing arrangement. Figs. 149 and 150 show the resulting ground effect to be negative, i.e., show loss of lift in ground proximity.

Some experimental data will serve to illustrate the various points. Figure 172 shows typical data from six different sources. The

ratio of lift to lift at large distance from the ground is plotted versus height measured in fan diameters. The dashed curve (ref. 71) is taken from helicopter experiments and shows only positive ground effect. Almost the same behavior is obtained with a thin shroud with a relatively sharp nosed airfoil profile duct carrying only 20% of lift (ref. 9). In contrast, a shroud with a well rounded inlet, (ref. 52), shows negative ground effect. The remaining three curves, (refs. 15, 16, 74), are for fan in wing arrangements and the ground effect is seen to be most adverse with the fan operating in a large plane.

IV. CONCLUSION

The ducted fan experiments reviewed cover machines which are quite different in characteristics; for example, area loadings of these machines extend from 4 psf. to 150 psf. Operational conditions for the machines also vary from nearly static operation to operation with considerable forward speed. Usually the task is to design for a range of varying operational conditions, thus all the features of technical compromise enter the picture. Conclusions that hold for a wide range of applications can therefore hardly be expected.

Some general priciples are apparent nevertheless. Gains in efficiency over the free propeller cannot be obtained by a shrouded propeller or fan. This is true for configurations designed for static operation as well as for forward flight operation and holds even if mutual interference between shroud and propeller is carefully accounted for in the design. In oblique flow (non-axial) operation the shroud may cause considerable complications.

The shrouded propeller can however produce higher static thrust than a free propeller of the same diameter and can do this efficiently if correctly designed for operation in the shroud. The ducted configuration also offers the opportunity to add stators easily. These are important for very highly loaded systems and it appears that in this area of extremely high loadings a case for the ducted fan can be made. The ducted fan configuration may also be the natural solution if the necessity exists to adapt a design to special constructive requirements, e.g., to stow away the fan for high speed flight.

It is evident therefore that the ducted fan system derives existence and justification more from constructive requirements and limitations than from aerodynamic considerations, i.e., from extraneous circumstance rather than from conditions inherent in the fluid mechanic problem.

V. LIST OF SYMBOLS

| A | propeller area $\frac{\pi d^2}{4}$ |
|----------------|---|
| A _e | area at shroud exit $\frac{\pi d_e^2}{4}$ |

$$C_{R}$$
 resultant force coefficient $\frac{R}{q_{0}A}$

$$C_{T}$$
 thrust coefficient $\frac{T}{q_{o}A}$

$$C_{N}$$
 normal force coefficient $\frac{N}{q_{0}A}$

$$C_L$$
 lift coefficient $\frac{L}{q_0^A}$

$$\overline{C_L}$$
 lift coefficient $\frac{L}{q_o c_s d}$

$$C_{\overline{D}}$$
 drag coefficient $\frac{D}{q_{\overline{O}}A}$

$$C_{\ell}$$
 rolling moment coefficient $\frac{\ell}{q_o A d}$

$$C_{m}$$
 pitching moment coefficient $\frac{m}{q_{o} A d}$

$$C_{p}$$
 power coefficient $\frac{P}{q_{o}Av_{o}}$

$$C_p$$
 static pressure coefficient $\frac{p-p_0}{(\rho/2)v_0^2}$

based on flight speed

- D drag
- d propeller diameter
- d_e shroud exit diameter
- d_h hub diameter
- d_S propeller specific diameter $\frac{J}{\sqrt{K_T}}\sqrt{\frac{\pi}{8}}$
- e lateral displacement of resultant force in a plane normal to the resultant vector (positive in negative y direction)
- e forward displacement of resultant force in a plane normal to the resultant vector
- f shroud profile camber
- h height above ground of duct exit plane
- J advance ratio, v_0/nd
- J_{p} propeller advance ratio, v_{p}/nd
- K_{R} resultant force coefficient, $\frac{R}{\rho n^2 d^4}$
- K_{T} thrust coefficient $\frac{T}{\rho n^2 d^4}$
- K_{N} normal force coefficient $\frac{N}{\rho n^2 d^4}$
- K_L lift coefficient $\frac{L}{\rho n^2 d^4}$
- K_{L_s} shroud lift coefficient $\frac{L_s}{\rho n^2 d^4}$
- K_D drag coefficient $\frac{D}{\rho n^2 d^4}$
- k ratio of reference area to fan exit area

based on propeller rctational speed

| | $^{\mathbb{K}}D_{\mathbf{s}}$ | shroud drag coefficient $\frac{D_{S}}{\rho n^{2}d^{4}}$ |
|---------|-------------------------------|--|
| 1 | K | rolling moment coefficient $\frac{\ell}{\rho n^2 d^5}$ |
| | Km | pitching moment coefficient $\frac{m}{\rho n^2 d^5}$ |
| | KP | power coefficient $\frac{P}{\rho n^3 d^5}$ |
| | К _р | pressure coefficient $\frac{p-p_0}{\rho n^2 d^2}$ |
| | L | lift |
| | $^{ m L}_{ m s}$ | shroud lift |
| | l | rolling moment about body axis |
| nn N | ^M o | free stream Mach number v_0/a |
| | M_{tip} | tip Mach number |
| | m | pitching moment about body axis |
| | N | normal force |
| I | n | propeller rotational speed |
| | ⁿ s | propeller specific speed $\frac{\sqrt{K_T}}{J^2}\sqrt{8\pi}$ |
| MIRCO | P | propeller power |
| -class | p | static pressure |
| | q | dynamic pressure $\frac{\rho v^2}{2}$ |
| 1 | R | resultant force |

based on propeller rotational speed

- R_e Reynolds number $\frac{\rho v X}{\mu}$
- r radial distance along propeller blade
- r' shroud inlet radius
- T thrust
- T_s shroud thrust
- t shroud profile thickness
- v velocity
- W weight
- X body axis in direction of the axis of rotation, positive forward
- Y body axis in lateral direction; positive to the right when viewed from downstream
- Z body axis normal to X and Y in a right hand system
- z number of blades
- α angle of attack, angle between propeller axis and free stream velocity
- $\beta_{.iR}$ propeller blade pitch angle at i percent radius
- $\beta_{\rm V}$ inlet guide vane angle, measured from axial plane (plus sign denotes flow deflection in direction of propeller rotation.)
- η efficiency $\frac{P_{ideal}}{P_{actual}}$
- $\eta_{\mathbf{F}}$ Froude efficiency $\frac{2}{\frac{v_e}{v_0} + 1}$
- $\eta_{\mathbf{P}}$ propulsive efficiency $\frac{-K_{\mathbf{D}}}{K_{\mathbf{P}}}$ J

| $\eta_{ m ST}$ | static efficiency $\frac{1}{\sqrt{\pi}}\sqrt{\frac{A}{A_e}} \frac{K_L^{3/2}}{K_P}$ |
|------------------|---|
| θ | tilt angle (angle between propeller axis and lift vector) |
| θ ! | angle between mean wake velocity and lift vector |
| λ | ratio of forward to tip speed $\frac{v_0}{\pi n d}$ |
| $^{\lambda}_{p}$ | ratio of velocity at propeller to tip speed $\frac{v}{\pi n d}$ |
| μ | dynamic viscosity |
| ν | hub ratio $\frac{d_h}{d}$ |
| ξ | shroud diffusion angle - angle between propeller axis and internal shroud surface of diffuser section |
| ρ | fluid density |
| σ | blade solidity $\frac{\text{blade area}}{\pi d^2 4}$ |
| σ' | ratio of fluid density to fluid density at sea level |

SUBSCRIPTS

- o refers to free stream condition
- p generally refers to propeller
- s generally refers to shroud
- tip generally refers to conditions at the blade tip
- ∞ generally refers to conditions at an infinite height above ground
- F front component of contra-rotating propeller
- R rear component of contra-rotating propeller
- ST generally refers to static conditions
- e generally refers to conditions at shroud exit

Two systems of forces are used; one is referred to body axes, (T, N) and the other to wind axes (L, D). Only two of the three moments are considered, pitching moment (m) and rolling moment (ℓ) and these are referred to body axes.

Two systems of coefficients are used and distinguished by K and C respectively. All K coefficients are referred to nd, i.e., to propeller tip velocity $/\pi$ and propeller diameter. All C coefficients are referred to forward or flight velocity and propeller disk area. These systems are used generally in the literature, however, variations occur with respect to constants (radius instead of diameter, factor π , etc) and of course with respect to the symbols used.

Some of the quantities not used in the present presentation but found more frequently are listed blow to facilitate orientation.

flow coefficient (compressors) λ_{p}

VI. LIST OF REFERENCES

- 1. Allen, J. J., and Rogallo, F. M. Ring Cowled Propellers
 Stanford University, Thesis, 1935
- 2. Chaplin, Harvey R.
 Theory of the Annular Nozzle in Proximity to the Ground David Taylor Model Basin, 1957
- 3. Claybourn, H. M., Sr.
 Study of a Shrouded Propeller with Distributed Suction on the Inlet Profile.
 Aerophysics Dept., Mississippi State University, Research Report No. 20, 1959
- Colton, R. F.
 Preliminary Engineering Report on the .4 Scale Aerodyne Model
 Static Tests.
 Collins Aeronautical Research Laboratory, Report No. CER-924,
 February, 1959
- 5. Dickmann, H. E., Weissinger, J.
 Beitrag zur Theorie Optimaler Dusenschrauben (Kortdusen).
 Jahrbuch der Schiffbautechnischen Gesellschaft, Band 49, 1955.
- 6. Eckert, B. Axialkompressoren und Radial Kompressoren Springer-Verlag Berlin/Gottingen/Heidelberg, 1953
- 7. Gill, W. J.
 Wind Tunnel Tests of Several Ducted Propellers in Non-Axial Flow.
 Advanced Research Division of Hiller Aircraft Corp.,
 Report No. ARD-224, April, 1959
- 8. Glauert, H.
 Airplane Propellers
 Div. L. of Aerodynamic Theory. W.F. Durand, Editor, Vol. IV
 Springer Verlag, Berlin, 1935
- 9. Gorton, J.V., Hamel, L. A. Aerial Jeep Vehicle Project - Phase I Final Report Chrysler Corporation, Defense Engineering, 1958

- 10. Grahame, W. E. A Review of Ducted Fan Research at Grumman Aircraft Engineering Corporation Ducted Fan Symposium at MIT, 1958
- 11. Greenman, R. N., Gaffney, M. G.
 Dynamic Stability Analysis of Ducted Fan Type Flying Platforms
 Advanced Research Division of Hiller Aircraft Corporation
 Report No. ARD-233, 1959
- 12. Grose, R. M.
 Wind Tunnel Tests of Shrouded Propellers at Mach Numbers from 0 to 0.60
 United Aircraft Corporation, Research Department, WADC Technical Report 58-604, 1958
- 13. Ham, N. D., Moser, H. H.
 Preliminary Investigation of a Ducted Fan in Lifting Forward
 Flight.
 Massachusetts Institute of Technology, Institute of the Aeronautical
 Sciences 26th Annual Meeting, New York, 1958. Preprint No. 827.
- 14. Helmbold, H. B.
 Range of Application of Shrouded Propellers.
 Fairchild Aircraft Division of Fairchild Engine and Airplane Corp.
 Engineering Report No. R221-011, 1955
- 15. Hickey, D. H. Preliminary Investigation of the Characteristics of a Two-Dimensional Wing and Propeller with the Propeller Plane of Rotation in the Wing Chord Plane. NACA RM A57F03, 1957
- 16. Hickey, David H. and Ellis, David R. Wind-Tunnel Tests of a Semispan Wing with a Fan Rotating in the Plane of the Wing. National Aeronautics and Space Administration NASA TN No. D-88, 1959

- 17. Hoehne, V. C., Wattson, R. K.
 Shrouded Propeller Investigations: Wind-Tunnel Tests of a
 Shrouded Propeller with a 17-Bladed Rotor, Inlet, and Exit
 Stators, and Long Shroud with High-Speed Inlet and No Exit
 Diffusion.
 Report No. 213-1, 1958
- 18. Hoehne, V. O., Wattson, R. K.
 Shrouded Propeller Investigations: Wind-Tunnel Tests of a
 Shrouded Propeller with a 17-Bladed Rotor, Inlet and Exit
 Stators, and Long Chord Shroud with Static Inlet and No
 Diffusion.
 Report No. 213-2, 1958
- 19. Hoehne, V. O.
 Shrouded Propeller Investigations: Wind-Tunnel Tests of a
 Shrouded Propeller with a 17-Bladed Rotor, Inlet and Exit
 Stators, and Long Chord Shroud with Modified Static Inlet
 and No Diffusion.
 Report No. 213-3, 1958
- 20. Hoehne, V. O., Wattson, R. K.
 Shrouded Propeller Investigations: Static Performance of
 Two Highly-Loaded Shrouded Propellers as Measured in the
 Walter H. Beech Memorial Wind Tunnel.
 Report No. 213-4, 1958
- 21. Hoehne, V. O.
 Shrouded Propeller Investigations: Wind-Tunnel Tests of a
 Shrouded Propeller with a 10-Bladed Propeller, Exit Stators,
 and Long-Chord Shroud with High-Speed Inlet and No Exit
 Diffusion.
 Report No. 213-5, 1959
- 22. Hoehne, V. O.
 Shrouded Propeller Investigations: Wind-Tunnel Tests of a
 Shrouded Propeller with a 10-Bladed Propeller, Exit Stators,
 and Long Chord Shroud with Static Inlet and No Diffusion
 Report No. 213-6, 1959
- 23. Hoehne, V. C.
 Shrouded Propeller Investigations: Wind-Tunnel Tests of a
 Shrouded Propeller with a 10-Bladed Propeller, Exit Stators,
 and Long Chord Shroud with a Modified Static Inlet and No
 Diffusion.
 Report No. 213-7, 1959

- 24. Horn, F.
 Modell und Grossversuche mit Kort-Dusenschiffen
 Schiffbau, Bd. 36, Nr. 10, pp. 178-180, 1935
- 25. Horn, F.
 Beitrag zur Theorie ummantelter Schiffsschrauben
 Jahrbuch 1940 der Schiffbautechnischen Gesellschaft
- 26. Hubbard, H. H.
 Sound Measurements for Five Shrouded Propellers at Static Conditions.
 NACA TN 2024, 1950
- 27. Hutton, S. P.
 Tip-Clearance and Other Three Dimensional Effects in Axial
 Flow Fans.
 Zeitschrift fur angewandte Mathematik und Physik, Vol. IX b,
 pp. 357-371, Germany, 1958
- 28. Johnson, A. E.
 Preliminary Investigation of the Effect of a Leading-Edge
 Slat on Static Thrust of a Shrouded Propeller.
 David Taylor Model Basin, Aerodynamics Laboratory
 Aero Memorandum 65, 1958
- 29. Kirby, R. H. Dynamic Stability and Control Characteristics of a Ducted-Fan Model in Hovering Flight. NACA RM L54C18, 1954
- 30. Knight, Montgomery, Hefner, Ralph A.
 Analysis of Ground Effect on the Lifting Airscrew
 NACA TN 835, 1941
- 31. Kruger, W.
 On Wind Tunnel Tests and Computations Concerning the Problem of Shrouded Propellers.
 Translation of ZWB Forschungsbericht Nr. 1949, January 21, 1944 by Mary L. Mahler, NACA
 NACA TM 1202, 1949

- 32. Kuchemann, D., Weber, J.
 Uber die Stroemung an ringformigen Verkleidungen
 (Concerning the Flow over the Covering of Annular Shapes)
 1942. Translated by H. R. Grumman Translation Report
 No. F-TS-620-RE, Headquarters Air Material Command,
 Wright Field, Dayton, Ohio, 1946
- 33. Kuchemann, D., Weber, J.
 Aerodynamics of Propulsion
 Chapter 6 The Ducted Propeller
 First Edition, McGraw-Hill Book Company, New York, 1956
- 34. Hayes, William C., Kuhn, Richard E., Sherman, Irving R. Effects of Propeller Position and Overlap on the Slipstream Deflection Characteristics of a Wing-Propeller Configuration Equipped with a Sliding and Fowler Flap.

 National Advisory Committee for Aeronautics, NACA TN 4404
- 35. Kuhn, Richard P, Draper, John W.
 Investigation of the Aerodynamic Characteristics of a Model
 Wing-Propeller Combination and of the Propeller Separately
 at Angles of Attack up to 90°
 NACA Report No. 1263, 1956
- 36. Lamb, H.
 Hydrodynamics.
 6th Edition, Dover Publications, New York, 1945
- 37. Lippisch, A. M., Navaratil, B. M.
 Wing Tunnel Investigation of the Forward Flight Characteristics
 of an Aircraft Model Composed of Two Shrouded Propellers.
 Collins Aeronautical Research Laboratory, Report No. CER-355,
 1954
- 38. Lippisch, A. M.
 Some Basic Derivations About the Action of a Shrouded Propeller.
 Collins Aeronautical Research Laboratory, 1956
- 39. Lippisch, A. M.
 Final Engineering Report on Wind Tunnel Test Study-Part I.
 Collins Aeronautical Research Laboratory,
 Report No. CER-826, 1958

- Lippisch, A. M.
 Engineering Report on the Results of the Wind Tunnel Testing
 for the 1/10 Scale Aerodyne Model.
 Collins Aeronautical Research Laboratory, Report No. CER-897,
 1959
- 41. Malayard, L. C.
 The Use of Rheoelectrical Analogies in Aerodynamics.
 North Atlantic Treaty Organization
 AGARDograph 18
- 42. Malavard, L., Hacques, G.
 Problemes de L'Aile Annulaire Resolus par Analogie Rheoelectrique.
 Laboratoire de Calcul Analogique du C.N.R.S., (Centre
 National de la Recherche Scientifique), Paris, France
- 43, Marcinowski, H.
 Optimalprobleme bei Axialventilatoren
 Heizung and Luftung, Vol. 8 (1957) 11, p. 273-285, and p. 295-296
- 44. Mathur, M. Ch.
 A New Simplified Form of Navier-Stokes Equations for
 Curvilinear Flow
 Aerophys. Dept. Mississippi State University, Report No. 24
 1959
- 45. McKinney, Marion O., Tosti, Louis P., Davenport, Edwin E. Dynamic Stability and Control Characteristics of a Cascade-Wing Vertically Rising Airplane Model in Take-Offs, Landings, and Hovering Flight.
 National Advisory Committee for Aeronautics, NACA TN 3198 1954
- 46. McKinney, M. O., Parlett, L. P.
 Flight Tests of a 0.4 Scale Model of a Stand-on Type of
 Vertically Rising Aircraft.
 NACA RM L54B16b, 1954
- 47. McLemore, H. Clyde, Cannon, Michael D.
 Aerodynamic Investigation of a Four-Blade Propeller Operating
 Through an Angle-of-Attack Range from 0° to 180°.
 National Advisory Committee for Aeronautics, NACA TN 3228
 1954

- 48. Minassian, B.
 Analytical Study of Shrouded Propellers.
 Longren Aircraft Company, Report No. PR-2, 1955
- 49. Minassian, B.
 Analytical Study of Shrouded Propellers
 Longren Aircraft Company, Report No. PR-3, 1955
- 50. Minassian, B.
 Analytical Study of Shrouded Propellers
 Longren Aircraft Company, Report No. PR-4, 1955
- 51. Minassian, B.
 Analytical Study of Shrouded Propellers
 Longren Aircraft Company, Report No. PR-5, 1956
- 52. Moser H. H., Livingston, C. L.
 Experimental and Analytic Study of the Ducted Fan and Fanin-Wing in Hovering and Forward Flight.
 Aeroelastic and Structures Research Laboratory, Massachusetts
 Institute of Technology, Technical Report 79-1, 1959
- 53. Moser, H. H.
 Analytic and Experimental Investigation of the Aerodynamics of the Ducted Fan.
 Massachusetts Institute of Technology, Thesis, 1958
- 54. Nelson, N. E.

 The Advantages of the Ducted Propeller in VTOL Aircraft Design.

 Doak Aircraft Company, Presented at the American Helicopter

 Society 3rd Annual Western Forum, Dallss, Texas, 1956
- 55. Parlett, L. P. Aerodynamic Characteristics of a Small-Scale Shrouded Propeller at Angles of Attack from 0 90°.

 NACA TN 3547, 1955
- 56. Patterson, G. N.
 Ducted Fans: Approximate Method of Design for Small Slipstream Rotation.
 Australian Council for Aeronautics, Report ACA-8, August, 1944

- 57. Patterson, G. N.
 Ducted Fans: Effect of the Straightener on Overall Efficiency.
 Australian Council for Aeronautics, Report ACA-9, 1944
- 58. Patterson, G. N.
 Ducted Fans: High Efficiency with Contra-Rotation.
 Australian Council for Aeronautics, Report ACA-10, 1944
- 59. Payne, P. R.
 Induced Aerodynamics of Helicopters Part IV.
 Aircraft Engineering, pp. 150-153, 1956
- 60. Platt, R. J.
 Static Tests of a Shrouded and an Unshrouded Propeller.
 NACA RM L7H25, 1948
- 61. Rethorst, Scott, Royce, W. W. Lifting Systems for VTOL Vehicles IAS Preprint No. 59-123, 1959
- 62. Sacks, A. H., Burnell, J. A.
 Ducted Propellers A Critical Review of the State of the Art.
 Contract No. NONR 2677(00)
 Advanced Research Division, Hiller Aircraft Corp. ARD-232
 1959
- 63. Sacks, Alvin H.

 The Flying Platform as a Research Vehicle for Ducted Propellers.

 IAS Preprint No. 832, 1958
- 64. Sacks, A. H.

 The Flying Platform as a Research Vehicle for Ducted Propellers.

 Advanced Research Division, Hiller Aircraft Corporation Preprint No. 832, 1958
- 65. Scholes, J. R. M., Patterson, G. N.
 Wind Tunnel Tests on Ducted Contra-Rotating Fans.
 Australian Council for Aeronautics, Report ACA-14, 1945
 Stanford University Library

- 66. Shects, H. E.

 The Slotted-Blade Axial-Flow Blower.

 Electric Boat Division, General Dynamics Corporation

 Presented at the American Society of Mechanical Engineers,

 Diamond Jubilee Annual Meeting, Chicago, Illinois, 1955

 Paper No. 55-A-156
- 67. Siebold, W.
 Naherungweise Berechnung des ummantelten Propellers
 Zeitschrift fur, Flugwissenschaften (ZFW), Bd 3, Nr 5, 1955
- 68. Soloviev, U I, Churmack, D. A.
 Marine Propulsion Devices
 Publ. by Military Publishing House, Ministry of the Armed
 Forces, Moscow, USSR, 1948. Translated by Rose Jermain,
 Science Translations Service, University of Alabama, STS-101,
 1951
- 69. Spreemann, K. P., Kuhn, R. E.
 Investigation of the Effectiveness of Boundary Layer Control by
 Blowing Over a Combination of Sliding and Plane Flaps in
 Deflecting a Propeller Slipstream Downward for Vertical take-off.
 NACA TN 3904, 1956
- 70. Spreeman, Kenneth P.
 Investigation of the Effects of Propeller Diameter on the Ability
 of a Flapped Wing, with and Without Boundary Layer Control,
 To Deflect a Propeller Slipstream Downward for Vertical Take-off.
 NACA TN 4181, 1957
- 71. Stepniewski, W. Z.
 Introduction to Helicopter Aerodynamics.
 Rotary Aircraft Series No. 3
 Rotorcraft Publishing Committee, Morton, Pa.
- 72. Stipa, L.

 Experiments with Intubed Propellers.

 L'Aerotechnica, Vol. XI, No. 4, 1931. Translated by A. A. Fanelli for Aerophysics Department of Mississippi State College, 1956
- 73. Stone, A.

 Ducted Propeller Development Status.

 Department of the Navy, Bureau of Aeronautics, Research Division
 Report No. DR-1910, 1957

- 74. Taylor, Robert T.

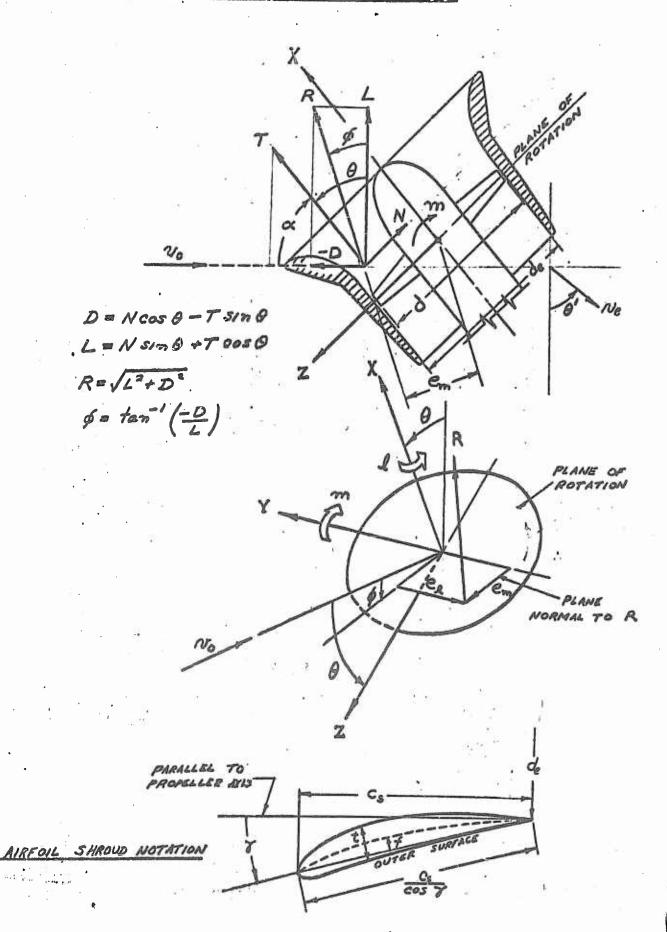
 Experimental Investigation of the Effects of Some Shroud
 Design Variables on the Static Thrust Characteristics of
 a Small-Scale Shrouded Propeller Submerged in a Wing.
 NACA TN 4126, 1958
- 75. Templin, R. J.
 Note on the Minimum Power Required for Flight at Low
 Airspeeds.
 National Research Council of Canada, Aeronautical Report
 LR-245, 1959
- 76. Tosti, Louis P.
 Transition-Flight Investigation of a Four-Engine-Transport
 Vertical-Take-Off Airplane Model Utilizing a Large Flap
 and Extensible Vanes for Redirecting the Propeller Slipstream.
 NACA TN 4131, 1957
- 77. Uberti, B. J., Reichert, J. B.
 Design Philosophy and Test Experience of a VTOL Aircraft
 IAS Preprint 59-122 1959
- 78. U.S. Army Transportation Research Command, Ft. Eusts, Va. Proceedings of A National Aeronautics and Space Administration (NASA) Briefing on Aircraft Research. 1959
- 79. Van Manen, J. D.

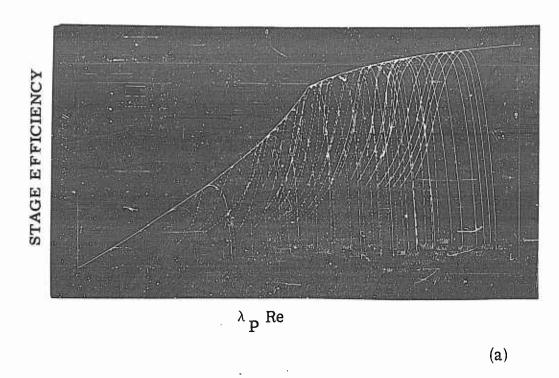
 The Design of Screw Propellers in Nozzles.

 International Shipbuilding Progress, No. 55, 1959
- 80. Van Manen, J. D.
 Recent Research on Propellers in Nozzles.
 Research Department, Netherlands Ship Model Basin, Wageningen
 Journal of Ship Research, pp.13-46, 1957
- 81. Van Manen, J. D.
 Open-Water Test Series with Propellers in Nozzles.
 Netherlands Ship Model Basin Publication No. 115a
 Reprinted from International Shipbuilding Progress, Vol. 1,
 No. 2, 1954

- 82. Vidal, R. J. A Theory of Wing-Propulsion Combinations in Slow Flight -Cornell Aeronautical Lab. Report No. AL-1190-A-1, AD 216 177, 1959
- 83. Wardlaw, R. L., McEachern, N. V.
 A Wing-Submerged Lifting Fan: Wind Turnel Investigations and Analysis of Transition Performance.
 National Research Council of Canada, Aeronautical Report LR-243, 1959
- 84. Whitehead, L. G., Wu, L.Y., Waters, M. H. L. Contracting Ducts of Finite Length Aeronautical Quarterly Vol. II, (1951), 4, p. 254-271

NOTATION AND AXES SYSTEM





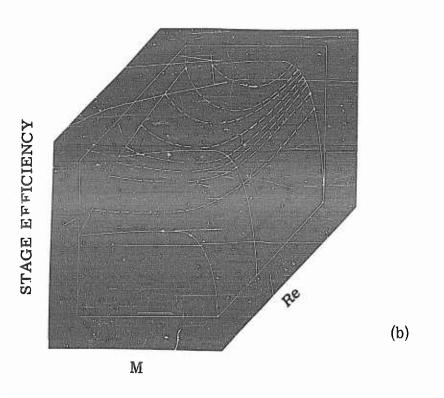
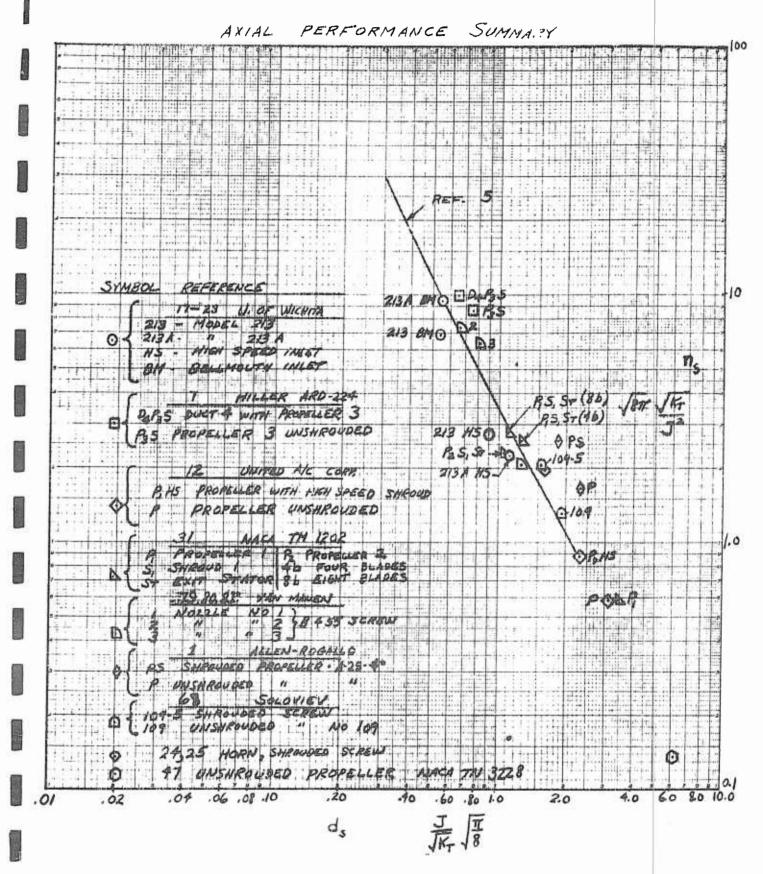


Fig. 4 COMPRESSOR PERFORMANCE AS FUNCTION OF REYNOLDS AND MACH NUMBER (Reference 6)

F16. 5



| PHEPARED | | Mark | PAGE | 141 |
|---------------------------------------|--|--|---------------------------------------|--------------|
| CH4-188D | | REPUBLIC | REPORT NO | |
| MEVISED | | | MODIL | |
| | | 87 | 186 | |
| | (122 | 2 9 9 9 | Evec. C | J 0 |
| | V V | 20 Z G G G G G G G G G G G G G G G G G G | 1.9 / Comp. 3.22.8 | 15/ |
| | | 8 7 % 66.00 | 0 K 2 6 | 97] |
| i i i i i i i i i i i i i i i i i i i | V V V V V V V V V V | | | 104 |
| \$ | \$ | Source Wales | 0 4 0 0 4 0 0 7 0 0 0 0 | |
| | 1- <u>4-2-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-</u> | | iestad auwo A ianie E | |
| | 8 | Aumos Rose, Um Rose, | A A A A A A A A A A A A A A A A A A A | 100 040/v |
| 0 7 | (3062) | 300027 | | |
| £16 | | 4 5 7 7 6 76 | 32320 | J'E |
| | 8 | | | N/A |
| | | 6 | 0 0 0 0 0 | |
| 282 | 3 | | | 3 |
| | | g | | |
| | * | | | |
| | | ROUDE ELLICK BLICK | | |
| | | \$1. Q wisheroone 0 | | |
| | | | | |
| | 9 8.9 | 2000 | 8 | 9 |

k ji je in

dior Willmon 2 UNITED NACA VAN MANEN 20 MOSMILL

7 GILL

12 CROSE

60 FLATT

31 KRÜGER

20,81 VAN MAN

25 JOHNSON

47 MCLEMORE-LIN

47 MCLEMORE-LIN

47 MCLEMORE-LIN 0 0 0 0 0 0 0 0 0.0 (:) 00

F +1 +10A REV, R/4E

5.14

Reference

17-23

Authors Source

Hoehne, V. O. and Wattson, R. K. University of Wichita, (7) Reports

Figs.

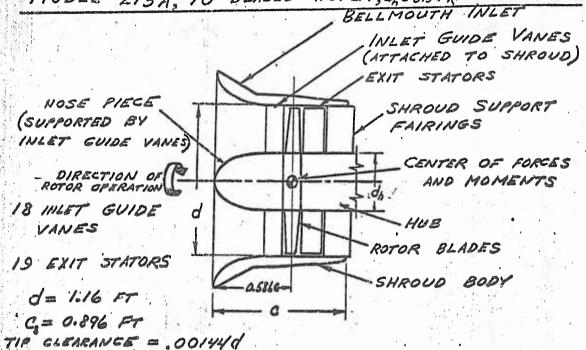
8-49

CONFIGURATION

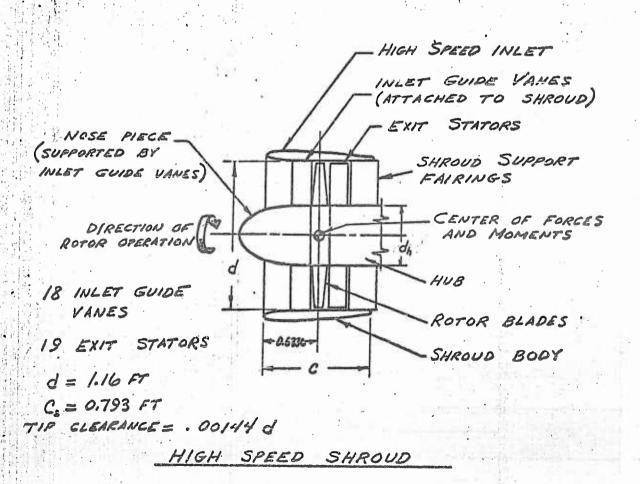
REFS. 17-23; WATTSON, R.K., HOEHNE, V.O.
U. OF WICHITA REPORTS 213-1, 213-7, 1958

MODEL 213, 17 BLADED ROTOR, d, = 0.4d

MODEL 213A, 10 BLADED ROTOR, d, = 0.3d (INLET VANES REMOVED)



BELLMOUTH SHROUD



| REVISEO | TE TOTAL PROPERTY. | | | - | HODEL _ | 1211111111111111 |
|----------------------------|--------------------|------|---------------------------------------|---|---------|------------------|
| | 8 | | | | | |
| | 8 | | | | | |
| | V | | | | | |
| | 3 | | စို့ ဝိ | | | |
| | 12 | | 2 19 19 | | | 00 |
| | | | 11/4/ | | | |
| | 0 | | / | | | |
| | <u>V</u> | | ■ | | | |
| | Ř | | | | | 3 |
| | | | | | | |
| | Ž | | рф 3 3 | | | |
| | 8 | | | | | |
| | | | ₹ | | | |
| | | | | | | |
| 1 1 1 1 1 1 1 1 1 1 | | | [| | | |
| | | 4 | 27 \ | | | , × |
| | 3 | | | | | |
| | 3 | 8 8 | 3 \ \ \ | | | |
| | · | ò %. | \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ | | | |
| S | 6 (2) | | | | | |
| 6 | 6 | | 8 | | | |
| | 30 | | | | | |
| | 557 | | | | | 98 |
| | 3 | | | | | |
| | 0 | | | | | anta e faiel |
| | | | | | | |
| | 498 | | | | | <i>i</i> |
| | a kilabasi i iga | | | | | |
| | | | | | | 4 |
| | | | | | | 4.0 |
| | 3 | 3 | 20 a 6 | | 9 | O |
| | | | (8) | | | 127111-111-11 |
| | | | 8 | | | |

が世界の

185 2-3-60 CHECKED 0

|OA | 49

182 2-1-60 19 % % % % % % 0 0 0

EV. 2/45

OA I 4F

JBS 2-1-60 148 471C (HRUST DIVISION)
471C (HRUST DIVISION) O, 0 3

E-1-10A REV, 2/49

3,

| PREPARED | TRS | 1-2-60 | | N. all | | 7 44 | PAGE | 149 |
|----------|--------------|---------------------|-------------|---|----------------------|--------------------|----------------|---|
| CHECKED | | | | REPUBLIC | | | REPORT NO | |
| REVISEO | | | | | | | HODEL | |
| | | | | 16. 13 | | | | |
| | | AXU | | PERFORM | | | | |
| REF | 18; | WATTSON, U. OF W | 614 1 | LI LI marilla de la | المتال المتال المرام | | | |
| | | | YOUEL | 2/3 | | | | |
| | | WITH | BELL | MOUTH | INLET | | | |
| | | | | | | | | |
| 20 | | | | | | Syme | 30L B 1———H | o° |
| | ×, | .20 1 o | | | | \$ \$\frac{1}{2}\$ | | 3° |
| 1.6 | X | .30 | | | | \$ |) /3 2 2 0 | 5° |
| K. I | X) | 1-10 0.3, | 则 | | | | | |
| /2 | \mathbb{X} | | 0 | 10 | | | | |
| | λ | 100 | $\Box \lor$ | 2,49\.45\ | | | | |
| 0.8- | | Je 1 | 19/2 | | | | | 100 100 100 100 100 100 100 100 100 100 |
| | | | | $\langle \chi \chi' \rangle$ | 30 | | | |
| 0.4 | | | | | 2 | 30 | | |
| | | | THE HILL | | | .10 | | |
| 0 | | 0.4 | 0.8 | R Z | 47/0 | 6 T | 2.0 | |
| | | | | | | | | |

1A 49 るとはいい

を開発を

差殊等

1ED SP 2-10-60 AXIAL PERFORMANCE

THRUST DIVISION

O.6 REF. 18; WATTSON, R. K. JR., HOEHNS, V.O.

U. O. WIGHTA PEPOLO 713-2, 1958 20°

| | PHEFARED | 2-3-60 | Mandalle) | : 21 | PAGE | 151 |
|-------------|------------|-----------------------------|------------------|---|------------------------|-------------|
| | MENINEO | astronomia | AVIATION | 5 5 .55.6 | MODEL | |
| | | | JG 15 | | | |
| | | | | | | |
| | REF. 17; W | PATTSON, R.K. JR. H | ERFORMANCE. | | | |
| | | 7 ii (15 jaul 114 ja 15 4 i | | HENDERSE | | |
| | | WITH HIGH SP | 213 EED INVET | | | |
| | | | | SYM8 | οι <u>βν</u> 2 -20° | |
| | 20 8 | | | 5 | -/o° | |
| | | 200 | | | /o° | |
| | 7.6 | | | | | |
| | K, 6 ° | | A | | | |
| | 1.2 10% | | | | | |
| | | | | | 1 1-1-1-1-1 | |
| | 0.8 | | 9 0 62 | | | |
| | | | 55 | | | |
| | 0.4 | 7 30 | 40 50 | X | | |
| | | | | X | | V V |
| | 0.4 | 0.4 0.8 Aova | 1.2 NOE RATIO | ile J | 20 | 2.4 |
| | | Aova | | | | |
| 10A 2/49 | | | | *************************************** | ellen lengt | 1111-1111-1 |

| PREPARED | 2-10-60 4 | ATPUBLIC AVIATION | JA. | REPORT NO | 152 |
|------------|---|--|-------------|------------------|-----|
| | | FIG. 16 | | | |
| | AXIAL | PERFORMANO | | | |
| 0.6 | THRUST F. 17: WATTSON | DIVISION | Haddallanda | | |
| | C. 05 W/ | CHITA REPORT | 2/3-/, | 1958 | |
| on. | WITH HIS | EL 213 H SPEED 11 | | | |
| 73 7 | 00_00 Bv | | SYMBO | 2 β _ν | |
| 0.2% | | 2 | | -/o° | |
| | 20° | F. 000 | | 70° | |
| | OAX O. | DVANCE D | | 2.0 710 J | |
| -02 | | | | | |
| | | | | | |
| -0.4 | Harai R | | | 8 | |
| | | | | | |
| -06 | | 41-11\ - 11 - 11 - 1 - 1 - 1 - 1 - 1 - 1 - 1 | | | |
| -06 -08 | | | V | | |
| | | | | | |
| | de distribution de la company | | | | |

| | | F/O | ş 17: | | | |
|---------------------------|-------------|-----------|------------------|--------------------|-----------------------|---------------------------------------|
| | | | 4 | in a second second | | |
| | | IXIAL PE | RFORMAN | | | |
| 12 at 2 at 1,22 letter to | REE 22 - 46 | ENNE V.O. | | NITA REP | 2/2-2 /26 | - 9 |
| | | 10DE4 2 | -13-:1-::10::10: | | | |
| | 850 | LMOUTH | INLET | | | |
| | | | | SYMBOL | B.8R | |
| | | | | 0 | 48.8° | |
| 2.0 | | | | | 28.8° | |
| | | | | | | |
| 1.6 | β.8A | | | | | |
| 1 /r 6 | 48.8° | | | | | |
| | 38.80 | | | | | 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 |
| | 17 | | | | | |
| | 2880 | | 2 | | | |
| 4 | 23.8 | #10 % S | | | | |
| | | 18/10 F | | | | |
| | | 30 | ? ? | \\ \\ \ \ \ \ | (4548) [72.3300, Al., | |
| | 04 | 0,8 | 1:11:72 | | 20 | |
| | | AOVA | | | | |

- 東京河南北

design to deliver

NA 4-1-60 154 REF. 22 HOENNE, V.O., U. OF WICKITS REP. 215 MODEL 213 A WITH -0.2

E-1-10A HEV, 2/49

Pl 3-3/-60 155 53.60° Symbol. D.8R Symbol. D.8R O 48.8° O 48.8° .0 88 48.80 4 VICE RATIO 2.0 0 PERFORM 8.80 W > 0 0 7 675 0005 .600 0 00 0

gd 3-3/-60 21 156 MODEL 213 A WITH MODEL 213 A WITH HIGH SPEED INLET 53.80 0 1 38.80 28.80 0 1.12 020 2.4 +02 E+1+10A RSV, 2/49

| PREPAREDCHECKED | 2-8-60 | ARFUBLIC AVIATION | PAGE _ | 157 |
|-----------------|-----------------------------|--|-------------------------------------|--|
| 9 | | 2/5-2/- | | |
| | NON | I-AXIAL PERFORM | 1ANCE | |
| 2.8 | tuteritife | SULTANT FORC | | |
| | | dend led open shed block to the trans- | NATTSON, R.K.J. 1. OF WICHITA RA | |
| 2.4 | | | 00EL 2/3 BELLMOUTH / By = 0 | * * ** * * * * * * * * * * * * * * * * * |
| | | | | <u>.</u> |
| 2.0 | | | | 0.2 0.7 1.4 |
| A | | | | ♦ |
| | | | 0.2 | 0 |
| /.2 | to the series of selections | | 9.7 A | pn2d4 |
| | | | | |
| | | | | |
| | | | $\mathbb{I}^{\mathbb{N}}$ | |
| 0.4 | | | | |
| | | | | |
| 0 | | 36' 60 TILT ANGLE | e | o i |
| | | | | |

7A 48

| | PREPARED | _28 | 2-4-60 | -1 | And . | | PAGE | 158 |
|----------------------|----------|---------|--|---------|--|-------------|-----------|--|
| | CHECKED | | | | REPUBLIC | 236 | REPORT NO | |
| | REVISEO | 50,2100 | THEORIGINE | | | | MODEL | ter much |
| | | | | | | | | |
| | | | | FIG | | | | |
| | | | NON- | AXIAL | PERFORM | ANCE | | |
| | | | | LI | - /- | | | |
| | | 2.8 | REP. | 18; WAT | SON, R.K. JR . A | OEHNE, V.O. | | |
| | | | | U or | WICHITA RE | | | |
| | | | | Mo | DEL 213 | | | |
| | | 2.4 | WIT | | MOUTH INL | ET SY | 180L J | |
| | | | | B | , = o | | 0.7 | |
| | | | | | | | Δ | |
| | | 2 0 | | | | K | | |
| | | 7.0 | 9 | | | | pn2d4 | |
| | | 2 6 | | | <u>\</u> | | | |
| | | | /_a | | \ | | | |
| | | 1.6 | | | | | | ###################################### |
| ¢* - | | | | | \ \\\ | | | |
| | | | | | 0.2 | | | |
| | | 1.7 | ###################################### | | | | | |
| | | | | | THE PERSON NAMED IN COLUMN | \^\ \p\ | | |
| | | | | | the state of the s | | | |
| | | 0,8 | | | | | | |
| | | | | | A SA | | | |
| | | | | | | | | |
| | | 0.4 | | | | | | |
| | | 0.7 | | | | | | |
| | | + | | | | | | |
| | | | | | | | | |
| | | 0 | Charles between a principal between | | | 60° | 90 | |
| | | | | | TILT ANG | 4 0 | | |
| | | | | | | | | |
| E+1-10A REV. 2/49 | 世界位 担闭组制 | | | | | | | |

| PREPARED | 2-4-60 | Mark | | PAGE159 |
|------------------|------------|-----------------------|---|--|
| CHECKED | | RIPUBLIC | | REPORT NO. |
| REVISCO | | | | MODEL |
| | | F15, 23 | | |
| | | -AXIAL PERF | | |
| | NON | DRAG | ORMANCE | |
| | REF. 18; W | OF WIGHTA RE | HOEHNE, V. | 2 1958 |
| | | | | |
| 3.0. | | MODEL 21 BELLMOUTH | 4-4-4 4-4 4-4 4-1 4-4 4-1 4-4 4-4 4-1 4-1 | |
| | | $\beta_{V} = 0$ | | SYMBOL J |
| | | | | 0 0.2 0 0.7 |
| 2.0 | | | | Δ 7.4 |
| K _P | | | | K _p = D |
| | | | | pn2d* |
| <i>/.o.</i> 0 | | | | |
| | | 14 | | ###################################### |
| | | | | |
| o | | -14- | E 0 | 90° |
| | | 0.70 | | |
| | | | | |
| -/;0 | | 0.2 0 | | |
| | | | 0 | |
| -20 | | | | |
| | | | | |
| | | | | |
| | | | | |

| CHECKED | l 2-4-1 | 60 .c | AVIATION | j) | f | REPORT NO. | 160 |
|---|-------------|------------|-----------------------------|-------------|-------------|---------------------|------------|
| | | | | | | | |
| | | | | | | | |
| | יו מי | - 18: 1/1- | POWER | MANCE | | | |
| | -6 | U. 04 | TSON, R.K. JR WICHITA RE | PORT 213 | 2, | 1958 | |
| | | WITH | MODEL Z BELLMOUTH | 13 INGET | | | |
| | | | β _ν =0 | | | SYMBOL | J |
| | 20 | | | | | р Ф | 0.7 1.4 |
| Kp | 6 44 | | J | | | | |
| <u>, , , , , , , , , , , , , , , , , , , </u> | 6 | 0 | 0.7 0 | | 3 3 1 | | |
| | | | | | | | |
| | 2 | | | | | $K_p = P$ $p n^3 d$ | |
| | 8 | | | | | | |
| | 8 | | | | | | |
| Ó | 4 | | | | | | |
| | | | | | | | |
| | | | O° | 600 | | 90° | |
| | | | | VGLE 0 | | | |

| PREPARED | god | 2-9-60 | (Like | | 71 | PAGE | 161 |
|--------------------|----------|--|--|---|--|---------------------|-----|
| CHECKED | | | (ACTATION) | 90 | | REPORT NO | |
| MEVIORO | | | , in the same of t | | | MODEL | |
| | araller. | DESTRUCTION DESTRUCTION | | HERMENESIS | ilitati di | ficality (Maintain) | 1 |
| | | | FIG 25 | | | | |
| | | | | | | | |
| | | | VAL PERFOI | | | | |
| | | | IROUD LIF | | | | |
| | 2 1 | 0. 1./1 | | | | | |
| | ZF. 1 | | ARKJE, HOEL | The second second second second second | Company of the Compan | | |
| | | | | | | | |
| | | | MODEL 21 | 3 | | | |
| | | 19 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 | BELLMOUTH | · 4-100 · 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 | | | |
| | | | | | | | : |
| | | | | | | | |
| | 2.0 | | | | SYMBO | 2 J | |
| | | | | | l.o. | 0.2 | |
| | | | | | | 0.7 | |
| | | | | | _A= | 1.4 | |
| | 1.6 | | | J | | | |
| | | | - X 1 X / | | | | |
| | | | | | | | |
| | | | | | 111/12 | 5 pn2d4 | |
| | 1, 2 | / | | | | pnede | |
| | | | | | | | |
| na dinian albertan | | | ₩ 0.7 | | | | |
| | Ţ | | 07 Q | | | | |
| | 0.8C | | | | friends and | | |
| | | | 0.2 | | | | |
| | | | | | | | |
| | 24 | | | | | | |
| | | | | | | | |
| | 0.4.6 | | 0.2 | | | | |
| | | | | | | | |
| | o | | | | | | |
| | | | 30° 7147 ANG | 60° | | 90° | |
| | | | TIAT ANG | LE 0 | | | |
| | | | 30° | | | | |
| | 11111111 | | ata: trendification | | (unidi) | | |

| PREPAREO | El | 2-9-60 | | and . | | 10 | PAGE | 162 |
|----------|-------|-----------------------|--|--|-----------------------|------------------------------------|-----------|--------|
| CHECKED | | - | * . | RIPUBLIC | | | REPORT NO | |
| REVISED | | | | | | | MODEL | |
| | | | | | | | | |
| | | | | FIG. Z | 6 | | | |
| | | | N - A Y / 1 | L PERF | DOM | سے سرور و | | |
| | | | SHRO | DA DA | AG | | | |
| | REF. | | | | | | | |
| | | 00 | F WICHT | REPORT | 2/3-2 | , 1958 | | |
| | 3.0- | | M | ODEL 2 | /3 | | | |
| | | W | TH BE | LLMOUTH | 1116 | = | | |
| | | | | q, = 0 | | | | |
| | | | | | | SYM8 | 04 1 0 | |
| | 2.0 | | | | | 0 | 0.2 | |
| | | | | | | | 1.4 | |
| - Ko | | | | | | | | |
| | | | | | | | Ko D |)s |
| | 1.0 - | | | | | | s pn | d* |
| | | \rightarrow | | | | 14 | | |
| | | | | | | | | |
| | 1 | | | | 0.7 | | | |
| | -0 | | 0. . | 30° | | | 900 | |
| | | et fact minimum and a | | 0.2 | 7/47 | ANGLE | 90° | |
| | | | and the last of th | | | | | |
| | | | | and the contract of the state o | | | | |
| | -1.0- | | | | | | | |
| | | | | | And the second second | | | |
| | | | | | | the last to be desired the self to | | |
| | | | | | | | | |
| | -2.0 | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | 11,1,1 |

to:

| CHECKED | gel | 2-9-60 | | | Jan. | | | 34 | PAGE | 16 | 63 |
|---------|------|------------|-------------|-----------|-----------|-----------|----------------|-----------|-----------|-----|----|
| CHECKED | | | | (The | REPUBLIC | | | | REPORT NO | | |
| HEVISEO | | | | _ | | | | | MODEL | | |
| | | | | | | | | | | | |
| | | NON-A | IXIAL | PE | RFO | RMAI | VCE | | | | |
| | | | 7 4 | | | | | | | | |
| | REF. | 18; WATTSO | | | | | | 58 | | | |
| | | WITH | MOD BELL | EL NOU | 2/3 TH | INLE | 7 | | | | |
| | 1.0 | | Br | =0 | | | | | SYMBO | | |
| | 08 | | | | | | 7 | | 0 | 0.2 | |
| | | | | | | X | | | Δ | 1.4 | |
| | 0.6. | | / | | -U | 0.7 | | | | | |
| | r | X | HINITH. | | | | | | | | |
| | 0.4 | | | | 0 | - 0.2 | | 4471 1000 | 37 HH 13 | = 0 | |
| | 0.2- | | | | | | | | | | |
| | | | | | | | | | | | |
| | o | | 30 | 0 | | GLE |) ⁶ | | 900 | | |
| | | | | TIL | T AN | IGLE | | ******** | | | |
| | | | diabilia la | | | | | | malu | | |

| | PREPAPED | GBP | 2-8-60 | | AVIATION | | .5 | REPORT NO. | 164 |
|----------------------|--|-------|--------|---------------|-------------|--|----------------------|------------------|-----|
| 5 | | | | | | | | | |
| | | | | | F/G. 28 | | | | |
| | | | | MON | PERFOR | | | | |
| | | | | | IR. , HOEHN | . 20 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 | 11111111111 | | |
| | | 0.5 | Mode | 2/ | 3 WITH B | ELLMOUT | W IN. | | |
| 東 | | | | | | Ј 1.4 | | SYMBOL | J |
| | | 0,4 | / | | | X | e _m | (∘ | 0.2 |
| | e _m | 4 | | | | | e, | | 0.7 |
| | | | | | V07 | | | | /m |
| | e _i | 0.3 | | 1111111111 | | | <u> </u> | V ₀ / | |
| | d d | | | | | V | | Yen | 49 |
| | | | | | | | | | |
| | | إنتتا | | | | | or for the second or | | |
| | | | | | 0.2 | | 1 | | |
| | | | | | | | | | |
| | I HER THE REPORT OF THE PERSON NAMED IN THE PE | | | 0 | 0.7 | | | W. | |
| | | | | 1 30 7/4 | | 60° E 0 | A Land Street Hall | 90° | |
| 1 - 10A REV, 2/40 | | | | | | | | | |

| | - | . V I | SE | 0 | - | | | - | _ | | | | - | | | | | | | | | | | | | - | | ŝ | | | | - (1 | HODE | EL | | _ | | - |
|---|-----|-------|-----|-----|----|---|-----|-----|----------------|-----|-----|--------|-----|------|-------------|-------|---------|------|------------|-----|-------------|------|------------|------|-----|-------|----------|------|-------------|-------------|-----|------|------|--------------|-----|-------|-------|-----|
| | | | | | | 1 | | | H | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | Ħ | | H | | | | | 1 | | | Ш | | | | H | # | | | F | 6 | | Z | 9 | | | | | | ₩ | | | | | | | | |
| Ì | | | | #: | | | | | | | E | | | | ij | | | | | ₩ | \parallel | Ш | | | # | | | | | Ш | | | ₩ | | | H | | H |
| | | T | | i | | | | i | | | | | | N | | U- | # | 1.0 | // | Z. | | 2 | E | - | 1 | - | | IN | | 5 | | | 卌 | | | iii | | Ť |
| | | ħ | | | | | | H | H | li | # | H | H | | 1 | TE | 5 | U | 77 | P | 1 | | # | 10 | R | C | | | | H | | liii | # | H | | | | |
| | | | | | | | | 2 | 8 | Ħ | 7 | PZ | F. | 7 | 7 | ٤ | h | A | 77 | -50 | V | , | ., | ٠, | 1 | 70 | E, | w | 20 | U | 0 | | | | | | | |
| | | F | | II. | | | li | | | | të | H | | | | | 4 | ć | 7 | 1 | 11 | c, | 11: | 14 | 1 | P | P | | 2/2 | 3- | 1 | 5/ | 19: | 58 | > | | | Ī |
| | | H | | | | | li | | | | H | | iii | | | M | 1 | 2 | _ مر | | | 2 | 2 | H | | , , , | | | | | | | 圃 | | | | THE | I |
| | 111 | | H | | | | II, | | 1 | | Ħ | | 111 | 1977 | *** | 24.81 | 1.2.2.1 | 4.14 | | £ , | 100 | 4.51 | 3.54 | | | | | Tij | | | | | | | Ħ | | lii | t |
| | *** | | | | | i | ľ | | | | H | | | | | | | | | | 1 | | III | | Ĩ | | | M | | | | | | Ħ | | | | I |
| I | | | | | | | E | | | | E | | | | | H | | A | Z | Ŧ | ø | | | | | | | | | | S | VM. | 801 | 2 | | J | 1 | |
| I | | | Ħ | | | | | | | !! | H | i | H | H | | | | | III | | | H | iii | III | | | | | | | | Ti. | | (11) | | 0 | | |
| | ::: | H | | | | | | , | | Ħ | | | | | | | | | | | | | | | | | | | | | | 0 | 111 | | ::: | 2,2 | | |
| | i | H | į. | | | H | 1 | | | | | | | | | | | | Ш | | : : | iii | | H | | | IIII | Hi | | | Ш | | 1111 | | ::: | 2,7 | 1:12: | 1 |
| | | Ξ | ij. | | | K | | | | H | | | į. | | | | | | # <u> </u> | | | | iii | | | H | | lii; | | | | Δ | | | 1 | .4 | | i |
| | | | Ħ | H | | | n. | | H | i | i. | H | Ш | | | | | | iii | | | | | | | 4 | \ | | | | H | | | | | | 15 | |
| | | | | | li | | | ۷. | | | | ij | | H | | | II. | | Ш | | | | | | Ш | | 1 | H | | | iii | J | | | | | | li |
| | | | | H | | i | | | | | | Ш | | lii | | | | | | H | 7 | | 0 | | | | 1 | | | | -0 | 2,2 | | \downarrow | | iiii | | |
| | | | | | | | | | | | | | | | | Ш | Щ | | | | \coprod | | | | | C | 7 | | 5 | | | | | Ø | | | 11:1 | |
| | | | | H | | | | | | Ш | | | | | | | | | | | | | | | | | | ١ | | | | | | | | | | |
| | | :: | žī. | | | | 14. | 4 | 2. | | | | | | | Ш | | | | | | Ħ | ÷ | lli: | | c | | | 弘 | | | 0.7 | | i | | 11::: | | L |
| | | | | | | | | | | | | H | | | | | | | | | | | | | | | | | \setminus | | Y | 7 | H | -0 | | 1111 | | |
| L | | | | | | | | Ш | ::: | | | | | | | Ш | | | | | 111 | | | | i | | | | | \setminus | | :::: | | | 11 | | 27.1 | |
| | - | | | | | | H | 440 | Ш | | | | Ш | 1 | | Щ | | Щ | | | Щ | Ш | | H | li. | Щ | | | | 4 | \ | 1 | 4 | | | | | |
| | | | | | | H | | o- | 8 | | | Щ | | | | Ш | ij | Щ | Щ | | Щ | | H | | | Щ | | | | | | / | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | ## ## | | | | | | | 717 | | | 1 | 1 | | | | |
| | | | | | | H | 11 | | | | | | | | | ₩ | | | 111 | | H | | | | | | | | | | 111 | | | T | | | | |
| | | | | | | Ħ | | | | | | 3 G 10 | | | \parallel | ₩ | | | | Ш | | | | | | | | | | | | | | | 111 | | | |
| | | | | | | H | H | 0 | 4 | 111 | 111 | 77 | | H | ₩ | ₩ | | | | Ш | | | | | 111 | | | 1111 | | | | | 1111 | | | | 1111 | |
| | | | | | | H | H | | | | | 111 | | | | ₩ | | | | | | | | | | | | | | | H | 1121 | | | | | | |
| | | | | | | | | | | | | | | | | | | | | Ш | 11 | | Ш | | | | | iii. | 1111 | | | 1111 | | | | | **** | |
| | | | | | H | | | | H | | 1 | | | | | H | | | | Ш | H | | | | | | | Ж | H | | | ### | | ₩ | H | | | 1 |
| | | | | | H | | | - | 2 | | | | | | | | | 2 | 0 | | H | 4 | 111 111 | | | 7 | . 0 | 1111 | | | | 1111 | 1 | - | 1.4 | | 1111 | |
| | | H | | | 4 | ш | | | | | 1 | | ₩ | | | | | 30 | 0 | | // | 4 | | | AA | 60 | 66 | | | 0 | | | 3 | o° | | | | *** |
| - | | | | | | | | | _ | | _ | | | H | | | | | i | | H | | H | H | | : 1 | | H | 111 | | | | | | | | 1111 | |
| | | i | | | | 밁 | | H | \blacksquare | | | Ш | H | Щ | 1 | Ħ | | Ш | Ш | Ш | Ш | # | Ш | Ш | Ш | | | Ш | Ш | | | Ш | | Hi | | 1111 | 1111 | 11 |

166 F16.30 NON-AXIAL PERFORMANCE -2-8 - REF- 17; WATTOON, P.K., HOCHINES V.O. U. a. MEMERA REP. 213-1, 1958 MODEL 2/3 WITH HIGH SPEED INLET 3,=0 1.4 0,2 600 TILT ANGLE 0

E -1 - 10A

| PREPARED | Jel 3-2 | 24-60 | 1x | | 39 | PAGE | 167 |
|--|---|--|--|--|---------------------------------|-------------------------------------|----------|
| CHECKED | <i></i> | | (XYXX) | | | REPORT NO | |
| REVISED | | * | AVIATION | | 4. | MODEL | |
| ENDER THE | i e e e e e e e e e e e e e e e e e e e | animestra in dis | | arcionalita | mounce | racino (2000) | 100 1000 |
| | | | | | | | |
| | | | FIG. | 37 | | | |
| | | | | | | | |
| | | NON-A | XIAL PE | REORMANO | الالحلا | | |
| | | | DRAG | | TEIHEF | | [mildel |
| | | | | | | | |
| | RE | F. 17; WAT | WICHMA | HOEHNE , V | 0, | | |
| | | U. or | WICHITA | REP 213. | 1,1950 | P | |
| | | | | | | | 7.77 |
| | 3.0 | Chief this paint is the company | DEL 2/3 | WITH | | | |
| | | HIGH | SPEED | INLET | | | |
| | | | By=0 | | | | |
| | | | | | | | |
| | | | | | SYM | BOL J | |
| | 20 | | | | | 0.2 | |
| | | | | | - | 0.7 | |
| | | | | | | 1/2 | |
| | | | | | | | |
| | | | | | | | |
| | | | in in idealen | | | | |
| | 7.0 | | | | | | |
| | | | | | | | |
| | and an experience of a final state of the | | | | | | |
| | | S. C - m.t = - k + 1 - 1 + 1 - m - + 1 1 | with the second state of the second state of | | | | |
| the second secon | | | | a martin a grant of American and the | | | |
| | | | | | | | |
| 法主要执行证法 | | قرا التالية التنالية | 7/47 | ANGLE | | 11190 | |
| the management of the state of the state of | | | | | | | |
| | the second second | | | proposition to be a proposition of the second transfer | or freedomination of the Parket | 14 | |
| | | | | I combigated as plained | the toget of the state of | \rightarrow | |
| | 4.0 | | | | b | 0.7 | |
| | -/.o. | | | | Hannie P | And the second second second second | |
| | | | | | م الم | 2 | |
| | | | | | IIII) C | 2 0 | |
| | | | | | | | |
| | | | | | | | |
| | -201 | | | 1 - 4 - 1 - 4 - 4 1 - 4 - 4 - 4 - 4 1 - 1 | | | 11-1-1 |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| 二二十二十二十二十二十二十二十二十二十二十二十二十二十二十二十二十二十二十二 | | | thr EHHERER | | | | ***** |

168 REF. 17; WATTSON, R.K., HOEHNE, V.O. U. OF WICHITA REP. 213-1, 1958 HIGH SPEED INLEY 0.7 GOO ANGLE

E +1 +10A

| PREPARED | ' 3-24-6a | Arthur REPUBLIC AVIATION | . ų 1 | PAGE |
|------------------------------|---------------------------------------|--------------------------|-----------------|----------|
| | | F-16 33 | | MODEL |
| | NON - AXI | 11 promon | NCE | |
| | | TONSION | | |
| | U OF WIGH | K., HOEHNE, V. | 1958 III | |
| | MODEL WITH ALCH | SPEED INLEY | | |
| | | | | 54MB02 J |
| | | | | 0 0.2 |
| 0.8 | | | 1.4 | |
| <u>Ls</u> <u>L</u> 0.6 | | | Д 0.7 | |
| | the termination of the first price of | | | |
| | | | | |
| | | | | |
| 02 | | | | |
| | | | 111270112812128 | 190° |
| | | TILT ANGL | ε ο | |

170 REF. 17; WATTSON, P.K., HOEHNE, V.O. MODEL 213 WITH HIGH SPEED INLET TILT INGLE Q

| PREMAUED | ges | 3-24-0 | áa | | | it. | | | 43 | | PAGE | | 171 |
|----------|--|--------|------|---|---------|----------------------|-------------|----------|--------------|--------|------------|----------|------------------|
| | | | - | | (Sta | REPUBLIC AVIATION | | | | | REFORT | NO | |
| MEVISEO | 712000 | , | _ | C 1 1 1 2 1 2 1 2 1 2 1 2 1 2 1 2 1 2 1 | | | | | | | MODEL | | |
| | | | | | E16- | 3 | | | | | | | |
| | | | | 111111 | | | | | | | | | |
| | | | NON | MOI | L PL | RFO | RMAN | CE | : | | | | |
| | | | 11.1 | | | | | | | | | | |
| | | | U | OF W | ICHIT | 3 HO | EHNE P-2 | 3-10 |). 195 | 8 | | | |
| | منزاندنا | | | | | | | | | | | | |
| | 0.5 | | MO | DEL | 2/ | 3 4 | 114 | | S | YMB | OL | J | |
| | | | HIGH | SPE | ED | INLE | 7 | ii.e | n | 0 | | 0.2 | |
| | | | | $\beta_{\nu} =$ | 0 | | | | | Δ | | 1.4 | |
| | 0.4 | | | | | | | | | Гſ | | 0.7 | |
| e, | <u>, </u> | | | | | | | iii e | 2 | K | | 1.4 | |
| d | | | | | | | | | | | | | |
| | | | | - 200. 2 | | | | | | | | | |
| | 0.3 | | | | | | (1.4 | 1 | | | | | |
| d | | | | | | | | | | | | | |
| | | ं वीहर | | | | | | | | - | | | |
| | 0.2 | | | | | | 0.7 | 1 | | *****1 | | | |
| 17-1-1-1 | | | | | | ال الا | | 1 | | ::::i | \i= | | h:::::: |
| | | | | | | ď | 3 | 15551111 | \mathbb{A} | | \= | | |
| | | | | | | | | | \mathbb{I} | 11 | | | age a service to |
| | 0.1. | | | | | | | | | 1 11 | | | |
| 起車車 | | | | | | | | | 1122 | mint I | | | |
| | | | | | 101 370 | million. | | | Ó | Lock | X | } | Fr. i |
| | o. | | | 36 |)° | e, a | 1.41 | | | -4 | $\simeq 1$ | 1 | |
| | | | | | | 147 | ANE | 25 | 0 | | | | |
| | | | | | | | | | 11.01 | | | | |

~

THE PERSON

PREPARED JES 3-25-60 172 NON-AXIAL PERFORMANCE RESULTANT FORCE REF. 225 HOEHNE, V.O., U. OF WICHITA REP. 213-6 ,1959 MODEL 213 A WITH BELLMOUTH INLET TILT ANGLE

| CHECKED | | | | | | (A. | REPUBLIC AVIATION |) - | | | ų (- | | | MEPORT NO | | | 173 | |
|---|--|---------------------------------|-----------------|----------------------|-----------|--------------|----------------------|-------|-------------------------|-------------------|---------------|-----|------------|-----------|-------|----------|----------|--------------|
| | | | NON | - 42 | IA | F | IG. PER | 3 | 7 | 111 | J.C. | | | | | | | 7 |
| | 3.2 | | | | Z | IF | 7 | | | 1.2 | | | | | | | | 700 |
| | | REF | ^{2}jH | DEHN | E, L | 1.0. | U.o | 2 | lic | HITA | K | EP. | 2/. | 3-6 | 3/2 | 75. | 9 | |
| | 2.8 | | MOL | DE Z | 2 | 13 | 4 | WIT | H | 8 | 544 | MO | UT | 4 | IN | EZ | | |
| | | | | | | | | | | 0 8K | | 4 | راح | 0 | 4= | | | |
| | | | | | \forall | | Bairtí Hilli | | | .8K | | | | | | | | 1 |
| | 24 | | | | | \backslash | | | | | | | | | | | | T. |
| | | | | /- | | | | | | | | | | | | | | |
| | | | 1 | (11:1 <u>1</u> : | | | | 4 | | | 1111 | | ری | IMB | | - | <u>7</u> | 200 |
| | | | / | | | | | 4 | | | | | | 0 | | 0 | 7 | 1000 |
| | 2.0 | | 7 | | | | | | 1 | | | | | Δ | | 1. | 4 | - |
| i K | | | / | | <u></u> | | | | 1 | | | | | | | | | A THE PERSON |
| | 4 | 1 | _0_ | | + | | | | $\downarrow \downarrow$ | | | | | | | | | 1144 |
| | 1.6 | | | | | 0. | | | | 4 | | | | | | | | 200 |
| | | | ۵_ | | | | 7 | | | | | | | 4 | | | | 1 |
| | | ***** | | | Q | | | 111 | | $ \cdot $ | 2014 | | 74 174 | | | ### | | |
| CONTRACT TRACTORS IN PROPERTY THROUGH THE | -12 | | 14141177 | | | 2 | | | /- | 1272 | | | 11: | | 122 | | | 0 |
| | hade joyed by | | | 1:11111: | | 11 4 4 4 5 | 8 | 11-21 | 11::1 | Ą | 1 | | | | 127 | | | |
| | | | | | | | | X | | \setminus | \perp | | | | | | | 11 |
| | 0.8 | | | 51.11 | | | | _ | - |] ຊ[| \setminus | _ | | | | | | |
| | | - II = II : | | A Daniel | 201 | | | | | 1 | \exists | 11 | : - | | | | | 1 |
| | Control of the Contro | | | -1-1-1-1-1 | 0 11119 | 1711 | | Heit | | | X | | | | | | | |
| | 0.4 | | | | Hiiii | | | | | 鯯 | | // | | 45 | | | | 1 |
| | | | | | | | | | | | | | / | | 12.12 | 4-15-1 1 | | 277.10 |
| | | | | | 1.11 | H:: | 計制部 | | | | | | -// | /- | | | | 77. |
| 4.0 4.4 0.7 9 Table 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 | | | the present and | | 11:1 | h:::: | | Im | | | | | 100 A Ford | 1 | | | | 100 |
| | | Company of the last of the last | | ق [[]] آال | o°. | | | | 6 | o°. | | | | Heir | o°. | | | C. C. C. |
| | | | | | | TI | Indigent of the | | IGL | Date and the last | | 0 | | | | | | 1671 |
| | | | | | | | | A | | 4 - 14 - 14 | edicina di di | | | | | | | |

を記る

が変いがあ

174 47 REF 22; HOEMME V.O. WOF WICHTA PER 213-6, 1959 3.02 1 MODEL 213 A WITH BELL MOUTH INLET TILT ANGLE 0 0.2

-1 - 10A

| CHECKED | <u>3-25-</u> 60 | AVIATION AVIATION | . | PAGE | 175 |
|---------|-------------------------------|---------------------------|----------|-------------|---------------------------------------|
| | | 79 | | MODEL | |
| | 6 1 4 4-4 1-4 4 4 4-4-4 4 4-1 | AXIAL REREC | | | |
| 2.8 | | POWER VESVIO, U.O. W | | P. 213-6, | 7959 |
| | מסמ (ניגק | -1 213 A W. MOU-H INZE | | Synboz 0 | J 0.2 |
| | | 8.8R = 48.8° | | 0 A | 0.7 1.4 |
| 2,0 | | | | 0 0,2 | |
| Ke & | | | , , | 0.7 | |
| | | | | | |
| h2 | | | | | |
| | | | | | |
| | | | | | |
| 04 | | | | | 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 |
| | 30 | o 60° | | | 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 |
| | 30 | • 60° 7/47 ANG L | e B | | |

)A 49

176 JEP 3-25-60 REF. 22; HOENNE, V.O. U. OF WICHITA REP. 213-6, 1959 MODEL 2/3 A WITH BELLMOUTH INLET

E - 1 - 10: REV. 27:

| PREPARED JE | 3-25-60 | Rule | 9.≎ | PAGE | 177 |
|-------------|---|----------------------|---------------------|-----------|--|
| CHECKED | | ALPUBLIC AVIATION | | REPORT NO | |
| REVISED | | | | MODEL | |
| | | FIG 41 | | | |
| | 1/04-44 | VAL PERFORMA | ا جي سرور | | |
| | 541 | POUD DAGE | | | |
| | | 1.0, 0. 00 WENTS | 1 in table 1 hard 1 | 218-6 , 1 | 959 |
| 3,0 | 3222 | 10074 111267 | | | |
| | | 8R = 488 | | | |
| 0.0 | | | <u></u> 57 | M804 J | 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 |
| | | | | A 1.4 | |
| | | | | | |
| lo e | | | | | |
| | | | | | |
| | | | | 900 | * **** * * * * * * * * * * * * * * * * |
| | Designation of the Company of the Co | YUT ANGLE | 0 | B 0.7 | |
| | | | | | |
| =/, o. | | | | | |
| | | | | | |
| -20 | | | | | |
| | \$40.4 · \$44.6 · \$44.4 · \$44.0 · \$4.0 · \$1.0 | | | | |
| | | | | | |

0A 1 49

178 51 MOMENTS REF. 22; HOEHNE, V.O. UOF WICHTA REP 213-6, 1959 MODEL 213 A WITH BELLMOUTH INLET B. = 48.8° 0,2 0.7 1.4 1.4 TILT ANGLE O 900 exto O.

| PREPARED | <u> 782.</u> | 3-27-6 | 2 | | | John . | | | , | PAGE | | 17 | 9 |
|----------|--------------|-------------------------|-------------|-----------------|-----------------|------------|--------------|-------------------------------------|------------------------------------|--|--------------|----------|------|
| CHECKED | | | | | Der | REPUBLIC) | | | | REFORT | NO | | |
| REVIEED | | | | | | AVIATION | | | | 44. 0.0 00 | | | |
| | | | - | nan danki e ku | CHARLESCHAFTER. | | 175701710700 | s across per | anyone lyeses | MODEL . | 2010012 | - | |
| | | PHE | Halitti | | | Mater | | | | | Hall: | 11:5 | |
| | 16703 | | | | | 4 | 2 | | | | | | |
| | i Ellia | THE STATE OF | 11111111 | 12(1) | | 7 | | Fill. | 11111111 | linilli. | Emple | 11:11 | |
| | | | | HARRE | | | | | | | | | |
| | 411.114 | | NON | 1- AX | AL | PER | ORI | TANO | CELL | | | 11:2 | :::: |
| | | | Hilly | 9ESUL | TAN | 711/ | ORC | : الباحي | | | | | |
| | | littlett | all their | la lille li | | | | | | | | | 11.1 |
| | 178 | | alifuil. | mili E | | r:Heili | rinifi | i i i i i i | | 11,17 | | e and | - |
| | | | relation of | | Ř≕H± | REF. | K of fr | DEHN | LES V. O LICHITA | | - | | 14 |
| | | | / | (Hellis | $\sqrt{1}$ | | U | OF h | LICHITA | REP | 2/3- | 60 | 19 |
| | | | <i>Y</i> : | MHH: | i Viii | | | | | | | 14=1 | |
| | | | 1 | | 111/11 | | 100 | ر اللوالي | 13 A | 111- | | | 111 |
| | 17.4 | 244 | , iiiiiiiii | | 12 711 | 1 | ******* | | | 4 . a . 4 see L . | | 1.71. | : :: |
| | | | | | | - B | **** | | 11 1 | COLUMN TO SERVICE STREET | | 122 | |
| | | 100 | | | | \ | | | 38.8 | o ::: 1 | | | |
| | | | | | | \ | 11/2 | .8R | | | | | **** |
| 71444 | | 田田田田 | HELLE | minis | | | | | | | | 130 | :::: |
| | 170 | | | EFFE | | 7 | | de la la | | <u></u> | | 7 | |
| | | | | | 音型型 | | | | HHII.T. | SYMB | The state of | <u>J</u> | |
| | | 12111111 | | | EHH | \ | шш | 1444 | | | er politica | 0 | |
| | (EEE) | | | | | | | | | :o | - C | 2.2 | - |
| | | J | | | | | \ | | | in. | H., | - | |
| | 16 | | | | | | λ | | | Δ | | 1 | |
| | | | | | J.,,,,,, | | -\= | | | | / | | |
| | | | | | \setminus | | $= \lambda$ | | | | 127/4/ | 1 | |
| | 1===0 | \Box | ЩЩ | | | | = | lillii: | | | | | H. |
| | /.2 | | O | THE C | C. P. 140 1 | <i></i> | 1445 | x 1111 | American Company of the Company of | | 50 | 1.1. | |
| 4.4645 | 1.6 | ******** | | | | | | 9 | | | 0.2 | | :;- |
| | | | | | | | | A SALES | | | | lini | |
| | | | | | 17.11.11.1 | | | $\mathfrak{g} \setminus \mathbb{I}$ | | | 7 | - | |
| | | | | | | | | 1 | 4554 | 1200 | τ | | |
| | | HHE | | | 出日前 | 15H2 | | | | | . 9 | hii f | 72 |
| | 0.8 | | | 11-11-11 | | | =111 | | | | | 100 | |
| | | | | | | | | | \ 0 \ | \sim | | | |
| | | 医医检查 医医皮 \$400 P | | division to a l | | | | | $1 \setminus \dots$ | | | land of | |
| | | | | | | | | 4 4 14 14 14 14 | $\parallel \lambda \parallel$ | | 1101 241 | 11 | |
| | | | | | | | | 144 | 11 | | | | 1 |
| | 0.4 | Hiller | | delleil | | | | | | | | HH.15 | |
| | | | | | | | | | | | things are a | | - |
| | | 14-14-1 | | | | | | | | | | 13. | = 1 |
| | | | | | | | | | | A REST TO STATE OF ST | History I | | |
| | | HEREN | | 聞問 | | | | | | | | | i |
| | | Hilliti l | Famili | :::::3¢ | 0 | | 11116 | o°!!! | | - Contract of the last of the | | 111. | i: |
| | | | | | | 7/47 | AI | o° VGLE | B | 9 | | | |
| | | | | | | | | | | | | | 110 |
| | | | | | | 7/27 | | | | | -1511111 | | ΞË |
| | | HHHH | | | | | | | | | | | Ħ |

DA / 48

| CHE | CKED | JBC | <i>3-29-60</i> | REPUBLIC AVIATION | 54 | REPORT NO. | 180 |
|--------|------------------------------------|-------|----------------|----------------------------------|--|--|-----|
| REVI | | | | | | MODEL | |
| | | | No | FIG 44 N-AXIAL PERFOR | | | |
| | | 2.8 | | 2/27 | | | |
| | | | | HORHWEZVO., WOF MODEL 213 A W | | A 213-6.1 | 258 |
| 1 | | 2,4 | | FLLMOUTH INLET | 1 compa 18-6-4-2 4-18-4-4-1-4 4 cc com | | T |
| | | | | | | | |
| | K | 2,0 | | | | SYMBOL J 0 0,2 0 0.7 | |
| | | 1,6 | | | | ⊒ Δ /.∳ | |
| | | 0 | | | | | |
| | | , , , | | 0772 | | | |
| 41111 | | | | 02 0 | | | |
| | | | | | | To the second se | |
| | | | | | | | |
| | | | | | | | |
| 521111 | | | | 30° 60 | alateratificate second | 900 | |
| OA | the state of the same for the same | | | | | | |

.

| CHECKED | 3-29-60 | A-A-REPUBLIC AVIATION | 5 ^L ss | REPORT NO | 181 |
|----------------|-----------------|-----------------------|-------------------------------------|--|---------------|
| | | 76 45 | | | |
| | NON-AXIIL | PERFORM | ا ا ا | | |
| | E DR | 46 | | | |
| | REF. 22; HOENNE | , V.O., V.O. | WICHITA REP. | 2/3-6, 19 | |
| 30 | MODEL 2 | 3 A WITH O | BELLMOUTH | INLET | |
| | | 7.8 | rtiggi. | | |
| 20 | | | 3 | MBOL J | |
| К _р | | | | 0.2 0.7 | |
| | | | | <u> </u> | |
| /.o.j | | | the same of the same of the same of | | |
| | | | | 1.4 | |
| 0 | | | | | |
| | | | 60° 7/47 ANGES 10 0 | 901 | |
| | | | | 0.7 | |
| | | | 0 | 0 0.2 | |
| | | | 0,0 | | |
| -20 | | | | | |
| | | | | titti::::::::::::::::::::::::::::::::: | kelejini ji - |

F ...

ged 3-29-60 _132_ POWER REF 22; HOEHNE, V.O., U. OF WICHTA REP. 213-6, 1959 MODEL 213 A WITH BELLMOUTH INLE A 1.4 E+1+10A REV. 2/40

| CHECKED | yel _ | 3-30-60 | AVIATION AVIATION | s.7 | PAGE 183 |
|----------|--------|---|-------------------|---------------|-----------------|
| | | | F1G 47 | | |
| | | NON- | AXUL PERFORM | INCE | |
| | REI | - 22 ; HOEH | NE, KO, U OF WIO | IIITA REP. 2 | 13-6 , 1958 |
| | | and a federate of the second of the court for | DEL 213 A W | | |
| | | | BBR = 38.8° | | умвос Ј |
| | 1.0 | | | | 0 0.2 0.7 A 1.4 |
| | 08 | | | 1.4 | |
| <u> </u> | | | | | 7 |
| | \$1277 | | | o. | 2.1.1.1 |
| | 01 | | | | |
| | | | | | |
| | 02 | | | | |
| | | | 36° 7167- AA | 60° 1GLE 0 | 95° |
| | | | | | |

e e

184 SHROUD DRAG PEF 22; HOEHNE, VO. U. OF WENTA REP. 213-6, 1959 310 MODEL 213 A WITH BELLMOUTH INLET

3-30-60 185 MODEL 213 A WITH

Reference

7

Author Source Gill, W. J.

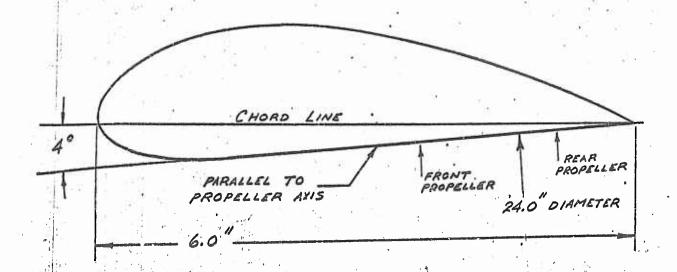
Hiller Aircraft Corporation

Figs.

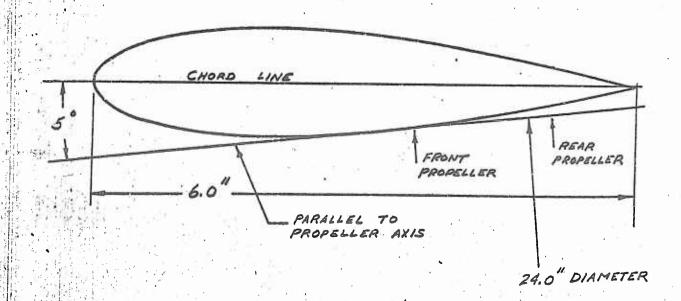
50-108

FIG. 50 DUCT CONFIGURATIONS

MODIFIED NACA 6421 SECTION



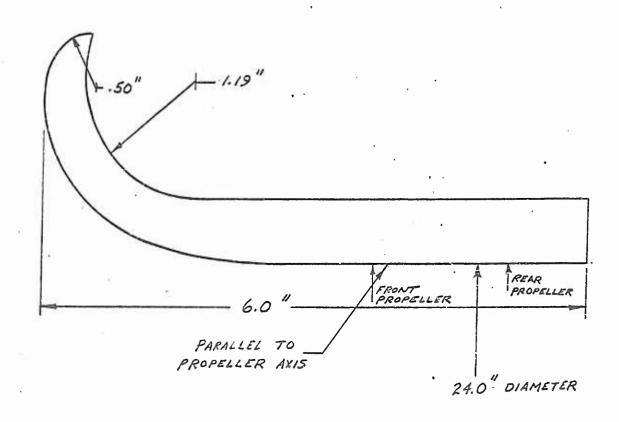
DUCT 2 NACA 0018 SECTION



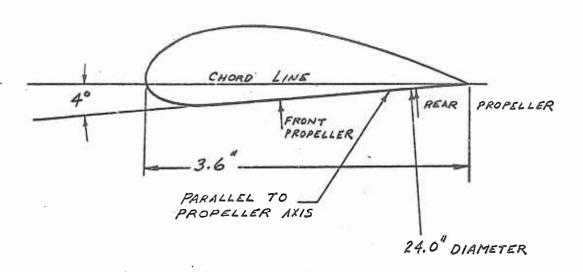
DUCT CONFIGURATIONS

REF. 7; GILL, W.J., HILLER AIRCRAFT COAP. ARD-224, 1959

DUCT 3 MODIFIED LEMNISCATE CURVE



DUCT 4 MODIFIED NACA 6421 SECTION



| CHECKED | Jol 1-31-60 | | REPUBLIC AVIATION | | PAGE | NO |
|---------|--|----------------------|----------------------|--|---------|----|
| MENISED | | | | | MODEL . | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | Annual Strategic | | | | | |
| | | | | | | |
| | 4/80 | | | to the distance of the part of the contract of | | |
| | | | | | | |
| MAN | n y | | | | | |
| 52.2 | 2 6 0 | | | | | |
| | 3 8 7 | | 0000 | | | |
| 5/2 | 1 | 2. 医克里氏性性支柱性炎 电力电子系统 | 1,1/1 2, 2 | | | |
| STATIC | 17 X | | DUCT DUCT DUCT | | | |
| Š | | 200 | 6666 | | | |
| | 7;611,41. | 4 % d | | | | |
| | | 。 。 。 。 | 100 | \ | | |
| | | 2 29 | \$ \$ \$ | | | |
| | | HOOUDED | 8 1 1 | | | |
| | |) ws H. | 8 | | | |
| | | | <u> </u> | | | |
| | | 3 00.0 | S | | | |
| | | | | | | |

190 PREPARED 185 1-22-60 111 11 1 STATIC PERFORMANCE

CLL, WJ HILLER AIRCRAFT CORP

P. OGELLER Z

OF THE CORP.

TO THE C

| PREPARED | 102 | 1-55-60 | A REFUSIIC | | PAGE | |
|--|--|---|--|---------------------------------|---------------------|-----------------|
| REVISED | | | AVIATION | | REPORT NO | |
| 10011-10-1 | Terretori | | reservation to the street | | HODEL | |
| | | | | | | |
| The best of the state of the st | allitte | HAMMIN LIFETTI | | | ltalettaku: | .02 |
| | 9 | | | | | 7 |
| | I W | | | | | |
| | 1.71 | | | | | Ęij. |
| | N. | | | | | |
| | N | | | taliji nadeni Samili | | 4 |
| | · N | | CONTROL BURGERS CONTROL BY THE B | | | |
| | 0 | | | | | = |
| | 2 | | | | | |
| | 117 | | the test and the first bearings to the first to the first and bear | | | N |
| | | \$7.60) | | | | `` |
| | The Market State of the State o | A S. P. S. C. L. L. S. L. | | | | |
| | 6 | | | | | FF |
| | | | | | | 0 |
| FE HERES | EVIII | (wrzw) | | | | Š |
| X 4 8 | 2 | | | | | |
| 8 | | Ŏ, | | | | Æ. |
| | 1 | | and the ball the contract of the ball of t | | | |
| | I N | 8 | | | | Ö |
| 54 | S | 9 | Maria Maria | | | .!D |
| 2 0 | | | i i i i n | | | |
| 666 | 1 | 2 | | | | |
| | × | 2 | | | | is. |
| STEELERS N | S | | | | | 0 |
| 18-4S | 3 | | (n | | | 11. |
| | H-4-11 | | | | | 픺 |
| | 13 | | и ф ф и и и и и и и и и и и и и и и и и | | | 4 |
| | 0 | | | | territory brownings | Ó |
| | E., 51 | | | | | |
| | N | | | | | |
| | | | 2/2 /v | | | |
| | Di- | | | a n | | 9 |
| | 3 | | 90 | ž ž | | |
| | | | | | | 1 - 1 - 1 - 1 h |
| | | | | | | |
| | | | 7,57 | Ö Ö | | marit. |
| | | 0 | | 4 | Ç |) |
| | | | | ò | | |
| | | | | | | |
| | | | | | | |

新

強をおき

| HEVISED | | | | | | | | | MODEL . | |
|----------------------------------|----------------|-----------------------------------|-----------------------|--------------------|--------------------|------------|----------|-------------------------|-----------------------|-----------------------|
| | - Dinbert | udil:Paine | ilu siesi | Fitzi: Li | linaur: | Hillion | dustrii | destes | lacine | Iterativa. |
| | | | | | | HHH | | | | |
| | 1 1 1 | | (m m 1 4 · 4 · | Acta Chically | | | | | Lancing Condition | l teller hærere. |
| | 2 | | | | | | | | HE HE | 11:1:1::: |
| | | | | | 11111111 | | | | | |
| and the state of the same of the | | | HHH | | Hilli | | | | bed to be ! | |
| | 1 6 | | | | | I million | | | 問題 | |
| | | | HILL | dista. | ****** | | | | | |
| | | | led: | | | | | | | |
| | 17 | | the let | | | | | | | -21:1-1 |
| | | | | | 14 4 4 4 4 4 4 4 4 | | | - S-+ | | |
| the state of the state of | V | | about much to a st | | 100 | | | | | |
| | TI 7 | | | | | | | | | |
| | U | | WHE | | | | | | | |
| | | | | | | | | | | |
| | | | Hill T | Uli ili ili | | | | | | |
| I. Try police and the | 1 1 | N | ilieji.s | | | 1,11111111 | Hali | | THE STATES | |
| | 3 0 ± 1 | | | | | | | | | |
| | 32 | 8 | | 5-point 4-fet-to | | - | | | | |
| ii U | N | | | | | | | | | |
| 16 | | | | | | | | | | |
| | N 4 1 | All books and the last the second | | | | | | | | |
| 1 0 | 222 | 0 | | | | | | | | |
| | 3 5 | | 777771 | | | | | | | |
| | Mattell | 7 III | | | | | | | | |
| | See and the | | | | | | ., | 1 | 4 | |
| | V . 7 | | 1.1.1.1.1.1 | 2011 | | or N | K. | | | |
| | 7 3 | | | 5 0 1551 HE UUI | | 200 | <u> </u> | | 5 | |
| | 2 | | Exercise Section 1994 | 5#### | | , To | 9 | 2500 | 3 | |
| | 2 3 | | | | | | | $= \mathcal{N}_{\perp}$ | 0== | |
| | | | | | | 中。 | | | | ¥#:::: |
| | | | | | 1 × | %d □ | II or ≪ | 0 | - | |
| | | | | | 100 | 60 | X | 0/2/08/ | D. | |
| | 1 | | | | | • \ | 3 | | 1. | |
| | #2 | | | | | थ्व | | | 70 | Signatural of |
| | | | | | | .° p | <u> </u> | | A comment to | |
| | | | | | | | | | A CHARLESTON CONTRACT | transfer (market and |
| | | | | | | | | | | |
| | HEE | | 門計劃 | | | | | | | TITE TO |
| | | | | 3 | 100 | 2 | | 2 | 11111111111 | |
| | | | | | | | | | | |
| | | | = w | | | | | | | |
| | | | | | | | | | | |

JR5 1-22-60 193 959 Hit 080 H 9 0 0 0 FIG. 56 AIR HILLER 19 V O III 8 Sma Sma NI 9 9 9 Halk I in the second of the se

*1 - 10A V. 8/ 40

*** 185 1-22-60 194 11 REPUBLIC AVIATION REPORT NO. REVISED HIMEN O Thrust Division

Thrust Care ARD-REA, 1953

Summissed)

Summissed) Fre 5 THRUST CROPELLER

Server Server

Server Ser SxAme S7.477

1 - 10A NA. 2/40

| PREPARED | 1-25-60 | (Lilea) | PAGE | 195 |
|---|--|--|---------------|----------|
| CHECKED | | AVIATION | REPORT NO | |
| MEVISED | | | MODEL | |
| | | | | |
| | | | | |
| | | | | |
| | STATIC V | ELOCITY SURVEY | | |
| REF. 7 3 | and the first term of the second seco | ER AIRCRAFT CORR AR | 0-224 19 | 59 |
| | | | | |
| | | | | |
| | | | | |
| | | | | 1 |
| | | | 2 3 4 3 | -/:= |
| | LIOUYFIED LEM | NISCATE SHROUD | INCHES | |
| | WITH PROPEL | NISCATE SHROUD () | | 11.1. |
| | | | | |
| | SHR | CUD EXIT PLANE | | |
| | | B-12° | | |
| 271 | | fluor trasher laborate a la laborate la la | | 17.0 |
| 9 | | η _s = 0.632 | | v |
| SOLY V | V | K-= 0-192 | | 15.09 |
| 28/FT# | | Ts/_= 0.44 | | |
| | | | | 170 F |
| | | | | / |
| SOLY Y | | | | 15.0 |
| | | | | p://// |
| | | ENTERBODY | | |
| | | | | |
| | | | | |
| | | | | 5-1:::1 |
| | SHROO | O EXIT PLANE | | |
| | | | medelene L | |
| jo je | | B-18° | | 170 |
| | | $\beta_{1R} = 18$ $\gamma_{c} = 0.7/0$ | | |
| 9 5.0 | | K = 0.318 | | 150 |
| | | K,=0.318 Ts/=0.45 | | 19 |
| /A° 0 () | | | | TO |
| | | | | |
| 50 | | | | 5.0 |
| | | ENTER BODY | | |
| | | | \rightarrow | |
| | | | | |

| | PREPARED | | TIES | 1-19-6 | | | | (| A.V. | REPUBLIC AVIATION | | | | | . | | PAG REP | 0#1 | 10 | | | _19 |)7_ |
|--------------------|----------------|-----------------|------------|-------------|----------|-------|-----|------------|------|----------------------|-----|------------|------|-----|------------|------|------------|-----|----|------------|----|------|-----|
| | | | | | | | | | 1/6 | | 6 | 0 | | | | | | | | | | | |
| , | | | | | | ÀΧ | IAL | | | 00 | 7.5 | or! | 7.47 | VC | <i>c</i> . | | | | | | | | |
| | | 0.7 | | REF | 7. | G | 22, | W | 7 | 7 | 111 | LER | Au | PCA | AFT | خالر | OK | 72 | AR | <i>p</i> - | 22 | 1.1. | 95 |
| | | | | P | ROI | PEL | ŽΕ, | R | 3 | w | 17 | 44 | DΖ | ے ر | | 4 | | | | | | | |
| | | 0.6 | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | |
| | | 0,5 | | | | | | | | | | | | | | | | | | | | | |
| | K _T | | | | | | | | | | | | | | | | | | | | | | |
| | |). / | | | | | | | | | | | | | | | | | | | | | |
| | | | | 0.17 | 0.25 | 0.34 | 9 | 41 | 0.48 | | | | | | | | | | | | | | |
| | | 0.3 | | 8 | 0.29 | 0.37 | 100 | , | 0.49 | 30° 27° | | | | | | | | | | | | | |
| | | | | | 0.32 | 100 P | 000 | / | 0.48 | 240 | β | 7 <i>R</i> | | | | | | | | | | | |
| | | | 7=0.2 | 7 | 7 | 0.44 | | | 72 | 10 | | | | | | | | | | Œ H | | | |
| | | 0.7 | 7=0.2 7 | 50:3 "1; | ó.4- | | | | 0 1 | 80 | | | | | | | | | | | | | |
| | | | | | | | | <i>'</i> ₽ | | | | | | | | | | | | | | | |
| | | | | | | | 0. | 4 | | | 7 | 6 | | | 2 | | | | | | | | |
| | | | | .0. | | A | Dν | AN | CE | | A. | 1776 | | J | | | | | | | | L. | |
| -1-10A V. E/ 85 | | | | | | | | | | | | | | | | | | | | | | | |

** A P. Co.

Marine Description

| MENINED | | | AVIATION | | | MODEL | |
|---------------------------------|------------|----------|------------|----------|---------|---------------|-----------------|
| | | | | 6/ | | | |
| | | | | | | | |
| | | 1 | | FORCE | 1000 | | |
| | REP. 7; G. | 22, W.V. | HILLER | AIRCRAFT | Cor | · ARD- | 22 |
| | P | ROPELLE | e 3 c | NSHROU | OED | | |
| | .24 | | | | 3 | 7180L | 7 |
| | | | | | | 0 -/- | 57 |
| | .20 | | | | | □ .3/ Δ .4 | 7/ |
| | | | | | | | |
| | .16 | | _0_ | | | * | |
| | | | | 0 1 | 9 0 | | |
| | | | | | J 14 | | |
| | | | Halletti 🖰 | | \sim | | |
| Burning the said this are the b | | | | ¥ 47 | , | | |
| | 08 | | | | | | |
| | | | | | | | |
| | .04 | | | | | | |
| | | | | | | | HI H |
| | 0 | | | ٠,٠ | | 100 | |
| | 0 | | 7/27 | ANGLE | 9 | 90° | |
| | | | | | | | 2 1 1 1 1 1 1 1 |

PHEPARED 12-25-60. 199 PROPELLER 3 UNSURBUDED 18

| | PREPARED | 93/ 3-25-60 | (LAN) | 75 | PAGE | 200 |
|------------|----------|---|--------------|-------------|---------|--------|
| • | REVISED | | ALEADING | | MODEL | |
| | | | | | | |
| | | | F16 63 | | | |
| | | · 大大大大大大大大大大大大大大大大大大大大大大大大大大大大大大大大大大大 | DRAG | INCE | | |
| | | REE T, GILL, W | DRAG | PAFT CORP. | IRD-224 | . 1959 |
| | | | | | | |
| | | 12 PROPE | LLER 3 UNSHA | OUDED | | |
| | | | B.TR = 120 | Sym | 80L J | |
| | | 6 | | | .157 | |
| | | -08 | | | 47.1 | |
| | | Q.01 N | | | | |
| | | | | | | |
| | | | 306 | o° ANGLE | | |
| | | HILL THE STATE OF | | | | |
| | | | | | | |
| | | .08 | k / | 471 | | |
| | | =-28 | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| 0A 1 49 | | | | | | |

| CHECKED | 2-25-60 | A REPUBLIC AVIATION | | REPORT NO | 201 |
|---------|--------------|---------------------|---|-----------|-------------|
| MEVISTO | | | | MODEL | zpanie o ze |
| | | FIG. 64 | | | |
| | NON- A | IVIAI PEEENDA | است سرو و و | | |
| | | POWER AIR | | | |
| RE | F. 7 5 G1449 | W.J., HILLER AIR | CRAFT C | ORF ARL | 2: |
| | PROPEL | LER 3 UNSH | ROUDEZ | | |
| | | PART TO THE | | SYMBOL | J |
| | | | | | 314 |
| | | | | | |
| | | -0-0-0-0- | ./57 |) | |
| | | | 374 | | |
| K, 06 | | | 47 | | |
| | | | | | |
| -04 | | | | pn2d4 | |
| ,04 | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | 30° 60° TILT ANG | 2 0 | 900 | |
| | | | H 1 1 1 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 | | |

. 41-1

| t | PREPARED . | FL. | 2-23-60 | | REPUBLIC AVIATION | | ÷ : | PAGE | 2.02 |
|--|----------------|--|---------|--|---|---------------------------|------------|----------|--|
| • | REVISED | | | | | | | MODEL | |
| # . # . # . | | | | ع ا | 16 6: | 5-11-111 | | | |
| | | | No | | AL PE MENT | RFORMAN | <u>ع</u> ی | | |
| | | :::::::::::::::::::::::::::::::::::::: | 7561 | 1 12 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 | 1 t (1 t 1 t 1 t 1 t 1 t 1 t 1 t 1 t 1 | AIRCRN | r CORP | A.P.D-22 | 4,1959 |
| The second second | | | | district dist | | UNSHROI | | | |
| | | | | | Λ: | | | | |
| | | | | | | | Syl | 1802 J | |
| ************************************** | | -20 | | | | | | 47/ | |
| | | | | | | | | | |
| | e _m | | | | | | | | |
| | d | ./2 | | | | the state of the ball of | | | |
| | | History : | | | | 医动物性动物 医动物性毒素 医卵髓中毒素 医神经病 | | | |
| | | 12 12 12 12 12 12 12 | | | | | | | |
| | | P | | | | | | | |
| | | 014 | | | | | | | A PRODUCT OF THE PARTY OF THE P |
| | i o | | | | D Street, Street, | | | 3/4 | |
| | | | | 30° 7147 A | NGLE | 600 | | 90° | |
| 2 · 10A | | | | | | A | | | |

| AKVISK | 0 | | · | | ******************* | | | | | | MODEL | | |
|---------|---|-----------|---------------------------|---------|---------------------|-------|-------|-------------|----------------------|--------------|------------|-----------------------------|---|
| | | | | Ma |)_ <i>4</i> y | F | G. G. | O MA | NC F | | | | |
| | | Trate Het | | 1111111 | 1911 4 | 1 111 | | 10 20 14 44 | 1 1 1 1 1 1 1 | | | | |
| | R | E.E. 7; G | 122, W | J. HII | LFR. | AIRCR | AFT C | ORP. | 430-22 | 4 19 | 59 | | |
| 11.11.1 | | | | P | ROPEL | LER | 3 UN | SHROU | 00 | | | | |
| | | .28 | | | B | n= /8 | | | | | | | |
| | | | \mathbb{P}_{\downarrow} | Lilli | Hill | | | | | | llille, | MBOL | 7 |
| | | | | | Į. | | | | | | | 0 | + 1 . |
| | | 24 | | | 3-7 | 2-15 | 6 | 7 | | | - & | БЩ | 31 |
| | | | | | | | 47 | 1 | <u> </u> | φ | و ا | | 47 |
| 4-7/11 | | | | | | | 46 | X | | | | φ <u></u> | o |
| | | | | | HH. | | | 314 | | | | | = : * - : : : : : : : : : : : : : : : : : : : |
| 1178100 | | .20 | | | | | | 中国 | | \mathbb{A} | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | ./6 | | | | | | | | 1 | | | |
| | R | | | | | | | | | | Ρ | b | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | -/2 | | | | | | | | | | | |
| | | | | | | | | | Salada Bahah Babahah | | | and district the section of | |
| | | | | | | | | | | | | | |
| | | .08 | | | | | | | | | | +++++ | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | 04 | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | 0 | | | - TIT | 0 | | | 00 | | 9 | 20 | |
| | | | | | | LT A | NGLE | 0 | | | 2 | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | 錋 |

T.

| | PREFARED | | A RPUBLIC MAINLAND | 43 | PAGE | 204 |
|---------|---------------------------------------|--------|-----------------------|-------------------------|-------|-----|
| | AKVIBEO | | | | MODIL | |
| | | Now-Ar | IRL PERFORMAN | المالية المالية المالية | | |
| 25 | REF | PROPEL | LER 3 CINSHROUL | 2 440 224 | 1959 | |
| | -28 | | Azn = 10° | | | |
| | | | | | | |
| | 0.24 | 1600 | <u>.</u> | | | |
| | | | | JYM (| 30L J | |
| | 20 | | | | .47/ | |
| | | | | | | |
| | / / / / / / / / / / / / / / / / / / / | | | | | |
| | -/2 | | | | | |
| | | | | | | |
| | . 08 | | | ¥. | | |
| | | | | | | |
| | 10/ | | | <u> </u> | | |
| | | | | | | |
| | 9 | 30 | o° 60 Tilt Angle 0 | ye | 70° | |
| E-1-10A | | | | | | |
| | | 8 2 | 3.00 | 1111 | | |

| PREPARED | REPUBLIC AVIATION | PAGE | 205 |
|----------|---|----------------|--------|
| REVISED | | MODEL | |
| Non | AXIAL PERFORMANCE | | |
| | DRAG HILLER AIRCRAFT CORP. | | |
| PAO, | OFILE 3 UNSHROUDED | ARO-224 1959 | |
| | B28 = 18* | | |
| | | | |
| 0.7 | | | |
| | | | |
| 6.2 | | Sүмвог J | |
| | | 0 /57 D 3/4 | |
| 0.7 | | | |
| | | 6 Pn145 | |
| Ko o | | 90* | |
| | | | |
| 0./ | | | Factor |
| | | 3/4 | |
| | 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 | <u> </u> | |
| 0.2 | 表示,大大的 医生态 的复数大规则 经免费 医皮肤性 医多种性 经基础 医多种性 医多种性 医多种性 经自由的 医电影 化二甲基二甲基二甲基二甲基二甲基二甲基二甲基二甲基二甲基二甲基二甲基二甲基二甲基二 | | |
| -0.3 | | | |
| -0:3 | | | |
| | | | |

1. 10A 1. 1/40 遊響

| | PHEPARED | • | and a | 5.1 | PAGE | 206 |
|-------------------|----------|------------------------------|---------------------|----------|-----------------|---------------------------------------|
| 403 | CHECKED | | REPUBLIC AVIATION | | REPORT NO. | |
| | REVISED | • | \bigcirc | | MODEL | · · · · · · · · · · · · · · · · · · · |
| | | Non-Axiaz | TIG. 69 PERFORMANCE | | | |
| | | | OWER | | | |
| | SE) | 7; GIL, W.T, HILL PROPELL | ER AIRCHAFT CORP. | ARD- | 724, 1959 UT | |
| | | Bra | <i></i> | | | |
| | | | | | | |
| 7 | | | | | | |
| | | | | s | YM004 J | |
| | -20 | | | | 0 | |
| | | | | | | |
| | | | | | | 1.2 2 |
| · va ¹ | 5-6 | | 0.47 | <u> </u> | | |
| | | | | | | |
| | | | | | | |
| • | .08 | | | шш | | |
| | os. | | | | | |
| | | | | | | |
| | | | | | | |
| | | 30° | ANGLE O | | 90° | |
| E -10A | | | | | | |

| PREPARED | REPUBLIC AVIATION | PAGE | 2.07 |
|--|--|--|-------------------|
| REVISED | _ | MODEL | |
| | FIG. 70 NON- AXIAL PERFORMANCE | | |
| | to a firm of the property of the contract of the first of | | 1 1 1 1 1 1 1 1 1 |
| REF 7 | MOMENTS GILL, W. T., HILLER AIRCRAFT CORR A PROPELLER 3 UNSHROUDED | PD-221, 195 | 7 |
| | Bar 180 | | , , |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | SVI | 180L J | |
| | | 0 157 | |
| | | ∆ .3/4 ∧ | |
| | | | |
| | | | |
| 1 | | | |
| | | | |
| | | | |
| | | <u>. [- - - - - - - - - - - - </u> | |
| 00 | | | |
| | * | | |
| | | | |
| | | | |
| | 107 | | |
| | | | |
| Cm. 04 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 | 30° 60° | 90° | |
| | 1/LT ANGLE O | | |
| | | | |

1 · 10A 2/49

| PREPARED | - 33 g | 2-24-60 | J. J. J. | 53 | PAGE | 2 |
|----------|---------------------------|---------|----------------|--------|---|----------|
| REVISED | | | REPUBLIC | | MODEL | |
| | | | | | | |
| | | | F16 11 | | | |
| | | | IXIAL PERF | | | |
| | .28- | | 15 W.J., HILLE | | T CORP. | |
| | | PROPELL | ER 3 AND DUC | 7 3 | | 19. |
| | 24 | | 75 = 1/20 | | MBOL | <i>[</i> |
| | | | | | 0 | 7 |
| | | .1570 D | | | A | 1 |
| | -204 | | | | | |
| 1 | 1 | | | | | 14 |
| | .16 | | | | | |
| | | | | | | |
| | 12 | | | | to come distriction for a family to any | |
| | ./2 | | | | | |
| | | | | | | |
| | | | | | | |
| | 1 - 1 - 1 - 1 - 1 - 1 - 1 | | | | | |
| | .01 | | | | | |
| 11555 | | | | | | h |
| | | | 200 | | | |
| | | | 7/47 A | 161E 0 | 90" | |
| | | | | | | 1 |

pl 2-24-60 209 28 REF. T; GILL, W.J., HILLER AIRCRAFT CORP. ARD-224, 1959 PROPELLER 3 AND DUCT 3

1/49

| MENISED | | AVIATION | | MODEL |
|--------------------------------------|---|------------|--|---|
| | | F/G 73 | | |
| | | | | |
| | · - • • • • • • - - - • • • | DRAG | The state of the latest and the late | |
| | 4 (5.0) () - 5 () () () () () () () () () (| | of a little land of the land of the land of | -P 4RD-22 |
| | REF. 73 GILLS W. | ER 3 AND 1 | 1000 | |
| | | 8-120 | | |
| | | | | |
| | | | | |
| | | | SY | 1806 J |
| | | | | 0 ./57 |
| | Y Light | 47/ | | □ .314 Δ .471 |
| | .314 | | | |
| | 157 Q | | A _D | $=\frac{D}{pn^2d^4}$ |
| | | | | |
| | | 730° | and in this thirt highly and and | 90° |
| executed frequents to be to be to be | | | | |
| | _04 \\ | | | |
| | | | | |
| | | YHIRMEHH | | |
| | = 08 \ | J=0 (-Kg | 57ηθ) | |
| | | | }-3-6-6-g-6-6-4-4-4-6-6-6-4-4-6-6-6-6-6-6-6 | |
| | =-a8 | | | |
| | | | | |
| | | | | |
| | | | | |

| PREPARED | | ; _ ; | A REPUBLIC AVIATION | | | PAGE | 0 | 21 |
|--|--|--|--|---|--|----------------------|-------------------------|------|
| REVISED | | | | | | NODEL _ | | |
| | | | | | | | | |
| | | | 1G- 74 | | | - 13.5 | | |
| | | | | | | | AND THE PERSON NAMED IN | |
| | | ON -AXIAL | DEPENDA | المسالم المسالم المراد و | | | | |
| | | SUPPLIE | - FEFFORT | 47068 | | | | |
| | | SHROUD | | | | | | |
| I I I I I I I I I | F. 7 ; G-12 | L,W.J., H. | ILLER AIRC | RAFT COR | 90 | ARD- | 224 | 3/ |
| | | | | | | | | |
| | | PROPELLE | R 3 An | D DUCT | 3 | | Internal Process | |
| | | · · · · · · · · · | 1R = 12° | | | | | 11.1 |
| | | | RTIC | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | 0.5 | | | | | 地描言 | | |
| | | | | | | | | |
| | | | | | | | | 3 |
| | | | | | | | | |
| | 04 | | | | SYMBO | 12- | \mathcal{J} | |
| | | | | | ⊞o | | 157 | |
| | | | | | - O | | 214 | |
| | | | | | | | 471 | #1 |
| | | | | | Section 1 | the let the price of | | 31 |
| | | | PROPERTY BENEFITS AND ADDRESS. | THE RESERVE OF THE PROPERTY OF THE PARTY OF | 111111111 | Local addition | | |
| 1/4 | | And the state of t | | | | | **** | |
| | The second second second | The second secon | | Property and the second | | | | Ti |
| | prompte de la fact de la contrata del la contrata de la contrata del la contrata de la contrata del la contrata de la contrata de la contrata del la contrata de la contrata del la contrata del la contrata del la contrata del la con | | | 21/2011/2011/2017 | 10 5 20 1 24 | | | |
| | AND RESIDENCE OF THE PARTY OF T | Light of the Article of the State of the Sta | construction of the state of the | | | | | |
| | | | the property of the second polynomials and | | 200 | Charles Co. Co. | | |
| A water and complete formation and accorded in our | | | | | 11 1111 | | | |
| | all the property between the same to | | | | | | 144 | |
| | 0.1 | | W-1 | 4.4.5.4.4.4.4.4.4.4.4.4.4.4.4.4.4.4.4.4 | | | 11:1:1: | |
| | <i>0-1</i> ф В | 1/57 | | 47/ | | | | |
| | | | | | 111111 | | 37713 | |
| | Hu::: ::::::::::::::::::::::::::::::::: | | 化克特特氏性 化氯甲基甲基化甲基苯甲甲基苯甲基 | 法检查性性的 医电子性性性性性性性 化二甲基二甲基二甲基二甲基二甲基二甲基二甲基二甲基二甲基二甲基二甲基二甲基二甲基二 | 1111 | | 15 41.4 | |
| | | | CONTRACTOR REPORTS STRATEGICAL SECTION | | 11 Y | | | Εŀ |
| | +14-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1- | :::::::::::::::::30 | | and the second of the second of the second of | A. D. Johnson, Phys. | :::::: | ACTION AND ADDRESS. | |
| | | | 7/47 | 10 h | | | 1301 | |
| | | | | | | | | |
| | | | | | er tettada | | | |

212 NON- AXIAL PERFORMANCE REF. 7; GILL, WJ., HILLER AIRCRAFT CORP. ARD-224, 1959 PROPELLER 3 AND DUCT .314

| PREPARED OBL | _ <i>3-17-6</i> 0 | ARPUBLIC | * | REPORT NO | 213 |
|--|---------------------|----------------------|---------------------------------------|---------------|------|
| | | 76 | | | |
| | NON- 1XI | AL PERFORM | ANCE | | |
| RST | 54 7; G122, W.J. | ROUD DRAG | | 180-214 | 1939 |
| | | ELLER 3 AN | | in the little | |
| a.3 | | B-1R = 12° | · · · · · · · · · · · · · · · · · · · | | |
| | | | SYMB | 01 J 151 | |
| 0.2 | | | □ □ □ □ Δ | .3/4 | |
| | | | | | |
| | Q .3/ | A11 | | | |
| | 00 | dit datameteralistic | ` ∆ ::: | <u> </u> | |
| | | | | | |
| -0.1 | | | | | |
| | | | | | |
| The state of the s | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

| PAR | PARKO | | 254 | 2-3 | 1-60 | | | | 6 | Ark. | | | | 8.1 | | PAGE . | | | 2 |
|---|--------|-------|---|---------|------------------|-----------|-----------|-------------|------------|----------------------|----------|------------|--------|------------|------------|-----------|---------|--------------------|------------|
| | CKED . | | | | _ | | | | F. S. | REPUBLIC AVIATION | fi o | · · | | | | MODEL | T NO. | _ | |
| IIII | Fiil: | Hilit | 1:1:1:1 | hi!iiii | iil lilli | iiii | Hi | Hii | Hii | | Figli | iiiiil | ijiji; | Hiii | | Hilli | | 7111 | 1 |
| | | | | | | Ħ | | FI | G | 77 | | | | 捕捕 | | | | | |
| | | | | | | | | | I | | | | | | 115 115 | | Ė | | |
| | | | | | NON | - / | 11/ | AL | H | PERI | FOR | M | INC | 4 | | | | | |
| | | | | | | | | 001 | W | R | 44 | | | | | | | | H |
| | | | RE | F. 7: | GIL | ۷,۱ | W.J | - | 412 | LER | AIR | CRA | FT | COL | جرم | AR | 0-2 | 224 | , |
| | 51 | | | | 111111 | | | | 4 1-64 | 3 4 | | 11:11 | | | | | | | li |
| | | | | | | | Gardine ! | | Ħ | | 20 | | | | Ĭ | | | Щ | |
| | | | 12 | | | | | ß | 7 <i>R</i> | | 1 | | | | | | | | H |
| | | | | | | | | | | | | | | | 壨 | | | | |
| | | | | | | | 54 | | | | | | | | <u>ځ</u> | YM80 | 2 | J | Ī |
| | | | | | | | | 1 | | | | | | | | \Q | | 0 | 1 |
| 5:: | | | .10 | | | | | Kp. | | 023 | 15 | | | | | 0 | | 157 | <u></u> |
| | | | | | | | | | 1 | | | | | | | | | 319 | |
| | | K | | | | | | E | | | | | | | | | | 4/1 | |
| | | | 08 | | | | | | | | | | | | | | | | Ē |
| | | | | | ^ | \$ | | \$ - | \equiv | > | φ | - ◊ | 711.1" | \diamond | 0 | | | | |
| | | | :::::::\ ::::::::::::::::::::::::::::: | | 0-0- | 8 | Ç- | <u> </u> | | 1.314 | | | | | | | | | |
| | | | | | Carbon of French | | | 0./ | 7 | J | | | Ha. | | | | | | |
| | | | .06 | | | | - | dieta. | | .47 | | | | | | | - | 11:11 | 1 |
| | | | | | | - | | | | | I word | | | | | | | | |
| | 齫 | | | | Halle | | | | H | | | | | | 111 | | A | 11 | 112 |
| | | | 04 | | | | | | | | | ### | | | | | Hi | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | 1111 | |
| | | | .01 | | | | | | | | | | | | | | | | 111 111 |
| | | | -02 | | | | | | Ш | | | | | | | | HE | HH. | |
| 337 | | | | | | | | | 11111 | 11211111 | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | Ħ |
| | | | | | | | 1111 | Hall | 1 | | | | | | | | | | |
| | | | | | | | 13 | o°. | | | | 60 | • | | | ٤ | 04 | - 1 - 1 - 1 - 1 | |
| | | | o | | | | | | 7 | 72.7 | AN | GL. | | Ø | | | | | - |
| | | ΗH | | | | | | | | | | | | | | | | | |

| PREPARED | 3L 2-24-60 | and the same of th | * | PAGE | 215 |
|--|------------|--|--|--------------|------------|
| CHECKITO | | (ACREPUSLIC) | | REPORT NO. | |
| BZVIOED | | AVIATION | | . MODEL | |
| | | n Las le Tendadidamalnamum | | ladra fraið. | Taring and |
| | | F16 78 | | | |
| | | | | | |
| | NON | - AXIAL PERFORMA | INCE | | |
| | | MOMENTS | | | |
| | | | | | |
| | 9EF 7: GIL | W.J. HILLER AIRCRAF | T CORP. | ARD 22 | 4. 1955 |
| | | | | | |
| | PRO. | PELLER 3 AND DUC | π::3::::I | | |
| | | | | | |
| | | | | | |
| | | | iiii isn | M802 J | |
| | | | | | , |
| | 20 | | | D 314 | |
| | | | | Δ -47 | , |
| | | | | | |
| | | | | | |
| | | 1/ .471 HELLER | | | |
| | | | | | Elii (|
| Em ! | | 事。[[],[[] 本 夕] 音音音 | | | 71 [11] |
| i d | | | | | |
| | | | | | |
| | | and the state of the property | | | |
| | | | | | |
| | 1 1 1 1/5 | 7 | | | |
| | 08 | | | | |
| | | | | | |
| Assessment of the Assessment o | | and become a first of the contraction of an interest because it was a first of the contract of | HHARIEL | | |
| | | | | | |
| | 04 | | | | |
| | 01- | | LX. | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | 10 | JO° 60° | | 11.90° | |
| | | | 0 | | |
| | | | elementario I resistante la propriata de la compansión de | | |
| | | | | | |

91 2.16 PROPELLER MOMENT REF. GILLIWI. HILLER AIRCRAF PROPELICE 3 AND DUST 3 me m -0.6. 100° | 90° | 90° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° | 100° - 10A 2/49

| PREPARED CHECKED REVISED | - Jay | 4-12-60 | | \$ *# | PAGE REPORT NO. | 217 |
|--------------------------|------------------|--|---------------------------------|--|--------------------|--|
| Covers and the | | | A/G. 8 | | | |
| | | No | N. AYIAL PE | REORMANGE | | |
| | 14 | METAN VITA REF. 7; | Grajus. | AND DRAG | | |
| | | | HILLER AIRCRAFT ARD-22F 1959 | Core | 1 | |
| | 1.2. | PROPEL B-18 | 168 3 AND DUCT = 12 | 3 / Ve 3/11 /Ve | | |
| | | ###################################### | .47), (° | | | |
| | //0 | | | | | |
| | 2/0 | | | | | |
| | Ç0.8 | | o¢ |) 0 0 0 (| | |
| | | | | No. | | |
| | 0.00 | | | | | 2 |
| | | | | | | |
| | | | | | | |
| | 0,2 | | | | | |
| | | | X | | | |
| | o | | 30° | ************************************** | | |
| | | | 30° TILT ANG | cs 0 1 | 90° | |
| 9 | elecencer page y | | | | | Till III III III III III III III III III |

*

3 2

| PREPARED . CHECKED . REVISED . | gad 4-13-60 | | R | AGE 2 |
|--------------------------------|--|-----------------------------|-----------|--------------|
| | | F/G 8/ | | |
| AEF T | , GILL, W.T. | AXIAA EXIT VELOC | B = 12° | E T= .47/ |
| | HILLER MIRERAFT ARD -224 , 1959 | Use of | | |
| | | | | |
| | | PROPELLER 3 | | |
| | | AND DUCT 3 | DUCT EXIT | PLANE |
| 0, | PRESSURE: 4.46 LB/ | (MIC) $\theta = 90^{\circ}$ | PAKE PO | SITION |
| 9e 5 | | γ ² · γ= ./77 | | |
| 10 10 | 0-0-0 | CENTERSODY | 0-0- | oo° |
| | | | | |
| | | | | PLANE |
| 9e | | 0 = 80° | | |
| 9e 10 5 | | | | 0 |
| 75°2 10 | | CENTER BUDY | | 0-0 |
| Je 13 5 15 2 10 (| | | | |
| | | | | |
| | | | | |
| | | | | |
| | ###################################### | | | |

| | PREPARED | Jul 4-13-60 | | PAGE 219 |
|---------|---------------------|---|--|-------------|
| | CHECKED | Military and interpretation of the state of | と語り | REPORT NO. |
| | REVISED | | | MODEL. |
| | | | 8/ / / | |
| | | -/- | Or. COWN | |
| | | NON-ACIAL | EXIT VELOCITY SURVEY | |
| | | | | |
| | | | | |
| | | | | |
| | (5) | ess steram by | DUCT EX | T PEANE |
| | PR | PESSURE = 4.46 (1/Fr.) | 9=70° | |
| | 98 | | | 90 |
| | | | 7 = .189 | |
| | <u>LB</u> | | | |
| | | | CENTERBODY | |
| | | | 10 ENV 2 R 300 / 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 | |
| | | | | |
| | | | | |
| 1 | | | DUCT EX | IT PLANE |
| | | | | |
| | | | 0=60° | |
| 40 M | 90 | | 7 = .192 | |
| * * * 1 | 28 | | | 15 |
| , N | F-2 | | CENTERBODY O | -0 0 LB FF2 |
| | 600 | | CENTERBOOY | 10 |
| | | | | |
| 7.7 | | | | |
| - 1 | | | מעכד בין | IT PLANE |
| 1 | | | | |
| | | | Ø=50° | 0 |
| | 90 | | | 9 90 |
| | £8 | | 7=.208 | 15 |
| | 28 52 | | | 上0 岩 |
| | 101 ₀₋₁₀ | 0-0-0 | CENTERBOOY O | ا فرا |
| | 0-0 | | | |
| | | Land and a 1 ft 1 m and 4 ft m and 4 ft m and 4 ft 1 m log 2 m d ft 4 ft 1 | | |
| -1-10A | | | | |

. .

| 0 | PREPARED | \$31 4.13-60 | | 1.6 | PAGE — REPORT NO | . 27 |
|-----|-------------|---|--------------------------|---------|------------------|------|
| | | | 51 CCON | اااااري | | |
| | | NON-AXIAL | EXIT VELOCITY | SURVEY | | |
| l . | | | و | uer exn | שנוניבק. | |
| | | FREE STREAM DYNAM PRESSURE = 4,46 62 ET |) 0 = 40° | | | |
| • | 5 Fr2 | | 9. η = 228 CENTERGODY | | ٥١٥ | 5 |
| * * |) O- | -0-1 | | | | |
| | | | 0=30° | OUCT EX | IT PLANE | - |
| | 18e 5 | | | 0 | ٥ر | 9 |
| | | | CENTERBODY A | | | 1/6 |
| | | | | OCT EXT | PLANE | |
| | ge j | | 0=20° | | | 9 |
| | le Frigo | م. | CENTERBORY A | | | 10 |
| | | | | | | |

| Снескев | - | 4.5-60 | · () | REPUBLIC) | | REPORT NO. | |
|--|---------|------------|--|-----------------------------------|----------|------------|-----------|
| REVISED | | • | | AVIATION | • | MODEL | |
| [| | | | | | | 15 (22.2) |
| | | | ا سے رہے | 82 | | | |
| | | | | | | | |
| | | NON- | AXINL PE | RFORMA | NCE | | |
| | | RE | SULTANT | FORCE | | | |
| | | | ا ا | | 1 | | |
| \mathcal{R} | / | 3 G1/L . N | J. SHILLER | AIRCRA | T Capp. | 4RD:224 | 2955 |
| | | PROP | LLER 3 | | | | |
| | | | | | | | |
| | II H5 | | $\beta_{77k} = 1$ | 87-11-11 | | | |
| | | | | | | | 1 |
| | | | | | | | |
| | 0.5 | | | | SYME | 106 J | |
| | | | | | | | |
| | | | | | | 314 | |
| | 14 | | | | | 471 | |
| III K | | | | | | | |
| | | | 471 | | | | FFI |
| | -0 | .157 | | | ### J= 0 | | |
| Property of the state of the st | 0.3 | 314 | 一门 | | | | |
| PHENNER BE | | | | | | | |
| | | | | | | | |
| | 0.2 | | | | | | |
| | | | Title III | | | | |
| | | | ····································· | | | | + - 'T-: |
| | | | | | | | • |
| | 0.1 | | at I will begin a self-male in a bound on it has | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | 30° | TILT AND | | ⊞ 90° : | |
| | | | | DODGE BUILDING BUILDINGS BUILDING | | | |
| | | | | | | | |

| PREPAREO | | <u>60</u> | (Lyken | | PAGE | 222 |
|--|---------------------|--|---------------------|--------------|--|----------------|
| REVISED | | | POLITAINA | | REPORT | NO. |
| | | | | | | |
| | | | FIG. 83 | | | |
| | | | F/G- 0.0 | | | |
| | | NON-AXIA | L PERFOR | MANCE | | |
| | | | FT | | | |
| | | | | | | |
| | REF 7 | ; G114, W. J. | HILLER | AIRCRAFT | CORP. ARD | 224,1 |
| | | | | | | |
| | | PROPELL | ER 3 AN | D DUCT | 3:11:11:11:11 | |
| | | | B.7R = 18 | 0 | | |
| | | | | | | 122557 |
| | | | | | | |
| | | | | | SYMBO | J |
| | | | | | ++++++++++++++++++++++++++++++++++++++ | .157 |
| | | | | | | .314 |
| | | | | | | .471 |
| | 0.4 | | | | | |
| | | | | | | |
| $ K_{L} $ | | | | | | |
| Testing and the property of the same of th | .15 | 0 - | △.471 | | | |
| | 0.3 | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | -0.2 | | | | | and the second |
| lastalinatesti | | | | | | |
| | | | | | | |
| | 0.1 | | | | | |
| | | and the best of the part of the contract of th | | | | |
| | | | | | | |
| | | | Acceptant interests | | | |
| | 0 | 1 | | 700 | 9 | |
| | | 30 |)° | 60° ANGLE | 0 | 0° |
| | | | | | | |
| B + - + + + + + + + + + + + + + + + + + | 1011111111111111111 | THE RESERVE OF THE PARTY OF THE | | | | |

| PREPARED JES | 4.5.60 | h. W. | , | PAGE 223 |
|--|--|--|------------------------------|---|
| CHECKED | grinnippomment i s man ny li neyon | REPUBLIC | | HEPORT NO |
| REVICED | | | | MODEL |
| | | | | |
| | | | | |
| | | FIG. 84 | | |
| | | | | |
| | NON- | AXIAL PERFORMAN | الالسيح | |
| | | DRAG | | |
| | | | | |
| | RFF 7 . G | ILL, W.J., HILLER AIRC | DIET C | 100 (PO 774 1959 |
| | | | | |
| | | POPELLER 3 AND D | والتارير | |
| | | OFECCER O AND D | | |
| | | B-18 = 18 | Traillieu. | |
| | | | | |
| | | | | |
| | | | | |
| 0.2 | | | YMBOL | |
| | | | oi.; | .157 |
| | | | | 314 |
| | | | Δ | 471 |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | 7147 | ANGLE | |
| | | | the landing of | ery terpinal marginal and a second second |
| | and the property of the same of the Land of | V 1 1 70 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 | eritativa esperante de | |
| the state of the s | | The state of the s | | |
| | | 1.757 | and the second second second | |
| | THE COURSE OF SHIPS AND ADDRESS OF THE PARTY OF THE PARTY. | | | |
| | and a finishment of the first o | | | |
| + 1111111111111111111111111111111111111 | | | | |
| | | | | |
| -02 | | | | |
| | | | | |
| | | | | |
| | A STATE OF THE STA | | | |
| | | | | |
| | | | | |
| | | | | |

JX 45.60 224 NON- AXIAL PERFORMANCE REF. 7; GILL, W.J., HILLER AIRCRAFT CORP. ARD :224, 1959 PROPELLER 3 AND DUCT B.7R - 18

| PREPARED | 4.5.60 | 102 | PAGE 225 |
|--|-----------------------------|------|-----------------|
| CHECKED | REPUBLIC | | REPORT NO |
| REVISED | | | MODEL |
| | A/G 86 | | |
| | NON-AXIAL PERFORMANC | | |
| | SHROUD LIFT | | |
| REF. 7 | GILL, W.J., HILLER AIRCRAST | CORP | APD-224, 1959 |
| | PROPELLER 3 AND DUC | 7 3 | |
| | Bi7R = 18° | | |
| | | | |
| 0.5 | | | |
| | | SY | 1802 J 5 157 |
| 0,4 | | | 3/4 |
| K_{4s} | | | |
| 6.3 | | | |
| Annual of the state of the stat | | | |
| 0.2 | | | |
| | 157 D D A 17/ | | |
| | -1/1 -3/4 | | |
| | | | |
| | | | |
| | 30° 60° 7127 ANG | 4 0 | 30 |
| | | | |

| PREPARED | JBP 4-5-60 | (Andrews | | 226 |
|------------------|--------------|---|----------|--------------|
| CHECKED | | REPUBLIC | • | REPORT NO. |
| REVISED | | | | MODEL |
| | | F1G 87. | | |
| | NON | AXIAL PERFORMANO | | |
| | | 41F7 DIVISION | | |
| - A | er 7 ; 6122, | W.J., HILLER AIRCRAFT | CORP. A | PD-224, 1959 |
| | PRO | PELLER 3 AND DE | 9 | |
| | | P7R = 18° | | |
| | | | SYMBOL | |
| | | | <u> </u> | .157 .314 |
| | 0.8 | | | .47/ |
| | | | | |
| | 0.6 | | | |
| | | and the form of the control of the first terminal property of the form to be form and the form to | | |
| | ./57_ | 0-/9-11-11-11-11-11-11-11-11-11-11-11-11-11 | | |
| Talker Haller Ye | | | | |
| | 0.2 47) | | | |
| | | | | |
| | | 200 600 | | |
| | 0 | 30° 7127 AA | igiz 6 | |
| | | | | |

10A RE 2/49

| PREPARED . 185 1-6-60 | | May 1 | | 227 |
|--|----------------------|------------|------------------------------------|--|
| CHECKED | | REPUBLIC | | REFURT NO |
| ntvisco | | | | MODEL |
| | | 8 | 8 | |
| | | | | |
| | | OUD DRA | G | |
| REF. 7; G11 | 1, W.J. | HILLER AIX | CRAFT CORP. A. | RD-224 ,1959 |
| | | | DUCT 3 | |
| 93 | | k = 18° | | particular for present the present of the present o |
| | | | | |
| 0.2 | | | SYME | |
| | | | | 3/4 |
| | | | | 471 |
| | 47/ | | | |
| | | | | |
| | 30 | | Trade of the contract to the first | · / 4 |
| | roma different entre | | | |
| -0.1 | | | | |
| | | | | |
| -02 | | | | |
| +1 -14 +1 -1 + 1 -1 + 1 -1 + 1 + 1 + 1 + 1 + 1 | | | | |
| -0.3 | | | | |
| | | | | |
| | | | | the term point to the selection of the second secon |

Brand Bloom

| 0 | PREPARED | | ko | . (D) | | 14.5 | PAGE 7 | 228 |
|----|----------|-----------------------------|--|--------|--|-----------|---------|---------------------------------------|
| | REVISED | | anger favoritation of a figure of the fine of a section of the fine of the fin | | AVIATION | | MODEL | |
| | | | | F/G | 89 | | | |
| | | | NON-A | XIAL , | PERFORMA | WCE | | |
| | | 4 | 1 | | | AFT CORP. | 100-501 | 7930 |
| | | and also have | 4 | | | 3 | | |
| | | | | B,78 = | 18° | | | |
| | | | | | | | | 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 |
| | | 20 | | | | - SYMBOL | | |
| | | | | | | O - | .314 | |
| • | | -16 | | | | | .47/ | |
| | <u>e</u> | | | 4 | | | | |
| | | 12 | | | | | | |
| | | printed to the state of the | THE THE | | | | | |
| | | .080 | 9 | 0.157 | | | | |
| | | | | | | | | |
| | | | | | printed to be production of the production of the printed of | | | |
| | | | | | | | | |
| | | | | 30° | | | | |
| | | | | | TUT | ANGLE | | |
| 68 | | | | | | | | |

| PREPARED JES | 4-6-60 | Carl. | 106 | PAGE | 229 |
|--|-------------------------|------------------------|---|-----------|---|
| CHECKED | | REPUBLIC) | | REPORT NO | |
| REVISED | 0 1 600 - minimum 1 pmm | | - | MODEL | |
| | | re 90i | | | |
| | | | | | |
| | | AL PERFORMANCES MOMENT | | | |
| RETE | 7 , GILL, W.J., | HILLER AIRCRAF | T COX | P. ARD-22 | 1, 1959 |
| | PROPELI | ER 3 AND DUCT | 3 | | |
| | برد فح ا | = 18 * | | | |
| | | | | | |
| | | | SYMBO | 157 | |
| | | | | 3/4 | |
| | | | | | |
| | | | | | |
| -0.6 m _e | | | | | |
| m | | | | | 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 |
| teddoring med to the control of | | | | | |
| | | | | | 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - |
| -0.2 | | | | | |
| and the same and the same and a read a | THE DESCRIPTION OF | D-0.314 | | | |
| | 257 A | | 111111111111111111111111111111111111111 | | |
| | 30 | GO° | 26 6 | 90° | |
| | | | | | |
| 0 | | | | | |
| | | | | | |

230 RESULTANT FORCE

REV. 7; GILL, W.J., HILLER AIRCEART CORP. ARD-224, 1959 PROPELLER 3 AND DUCT 3 B.7R = 24°

| PREPARED | gel 2-2 | 2-60 | (Like | 11 | PAGE |
|----------|---------|---|------------|-------------|--|
| CHECKED | | | REPUBLIC | 1 | REPORT NO |
| MEVISED | | | | | MODEL |
| | | | FIG. 92 | | |
| | | | F1G. 12 | | |
| | | NON-AX | IAL PER | FORMANCE | |
| | REF. 7 | ; G142, W.J. | HILLER | AIRCRAFT CO | P. ARD-224, 1959 |
| | | | | O DUCT 3 | |
| | | | BIR = 24 | | |
| | | | | | |
| | | | | SVMB | 0 <u>L</u> J |
| | 0.5 | | | | .314 |
| | | | | | .47/ |
| | | ./57 ₀ -0 | | | |
| i i o | 0.40 | 3/4 0 0 | | | |
| K, | | | | | |
| | 0.3 | | | | |
| | | | | | |
| | HE LEHE | Andred Edul | | | |
| | | | 2122134634 | | |
| | | | | | |
| | 0./ | -1-1-71-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1 | | | |
| | | | | | |
| | | | | | |
| | | 30° | | | The state of the s |
| | | | | | |
| | | | | | |

British Ballet

Prophysics (F

232 NON-AXIAL PERFORMANCE REF. 7; GILL, WJ., HILLER AIRCRAFT CORP. ARD- 224, 1959 PROPELLER 3 AND DUCT 3 Bin = 24° TILT ANGLE

233 Se 2-29-60 NON-AXIAL PERFORMANCE POWER AIRCRAFT CORP. ARD-224 1959

1 · 10A 2/49 234 REP. 7; GILL, W.J., HILLER AIRCRAFT CORP. ARD-124 PROPELLER 3 AND DUCT 3

| PREPARED | 2-29-100 | And | 112 | PAGE 235 |
|--|---|--|--------------------------|------------|
| CHECKED | - | REPUBLIC | • | REPORT NO. |
| REVISED | | est la galishipa at a l'annado an galantina a comitiva attenda a | r | MODEL |
| | | EIG 96 | | |
| | | | | |
| | 11.512 25 25 25 25 25 25 25 25 25 25 25 25 25 | TOLVISION | | |
| | | J. HILLER AIRCRAF | | |
| | PROPE | LLER 3 AND DU | | |
| | | BITR = 24° | | |
| | | | | |
| | | | | |
| 4.0 | | | | |
| | | | SYM | 80L J |
| 0.8 | | | <u> </u> | 314 |
| Z _s | | | | |
| 0.6 | | | 1 | |
| | | 377 | | |
| | | | | |
| | 40 | | | |
| | 311 8 | | which to be to be before | |
| The state of the s | 317 8 | | | |
| | | | | |
| | ************ | | | |
| | 30 | 0° 60° 7127 ANGLE | 9 | 90. |
| | | | | |

| | PREPAREO | 782 | 2-29-60 | | State of the state | PAGE | 236 |
|----------------------|----------|---------------------------------------|---------------------------------------|---------|--|--|----------|
| | REVISED | | | | AVIATION AVIATION | REPORT NO | |
| | | | | | 16. 97 | | |
| 12 | | | Non- | AXIAL | PERFORMANCE | | |
| | <i>A</i> | EF. 7; | * * * * * * * * * * * * * * * * * * * | | DRAG AIRCRAFT CO. | RP. ARD-224, | 93-9 |
| | | 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 | | PROPELL | ER 3 AND DUCT | | |
| | | | | B | 7A = 2A° | | |
| | | 0.3 | | | | | |
| | | | | | | | |
| | | 42 | | | | SYMBOL | <u>J</u> |
| | | | | | | | 314. |
| | | | | | | | |
| | 05 | | 7 | 314 | | P5 P72 | |
| | | 0 | 157 | | | 000 | |
| New County | | | | | TILT ANGLE | (A) (B) (B) (B) (B) (B) (B) (B) (B) (B) (B | |
| | | | | | | | |
| | | | | | | | |
| | | -0.2 | | | | | |
| | B | | | | | | |
| | | -0.3 | | | | | |
| E - 10A IEV. 2/49 | | | | | | | |

| PREPARED | 185 | 2-29-60 | | 1 | de | | | | PAGE | ······································ | 237 | |
|--|---------------------------------------|--------------------------------|---|---------------------------------------|-----------|----------|---------|-------------------------------|------------|--|---------|------|
| CHECKED | | | | (Are | EPUBLIC) | | | • | REPORT N | | | |
| REVISED | · · · · · · · · · · · · · · · · · · · | | | \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ | ZIATION | | | | MODEL _ | | | |
| | i Ingilitai | | hedraide i | hallahi | | heilidik | i (Tai) | Essissi | liis listi | | Tionia. | Ja |
| | | | | | 00 | | | | | | | |
| | | | | 16 | 10 | | | | | | | |
| | | NON- | | | | | | | | | | |
| | | HINON: | MAL | ع ربر ا | KFO, | RMAN | CE | | <u> </u> | | | |
| | | | MON | JENT | | | | | | | | |
| | REF. | 7; 610 | L, W. J. | , H12 | LER | AIRCR | AFT | COR | 19. 1 | RD- | 224,1 | 95 |
| | | PQ | 00511 | ER | 3 . | ND 2 | טעם | | , | | | |
| | | | | | | | | | | 136 | | 1 |
| | | | | P.78 | | | | | | | | lia. |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | 1 |
| | | | | | | | | | | | lë Hiii | |
| | ,20 | | | | | | | | | | | - |
| | | | | | | | | | - 15 | | | ± |
| | | | | | | | Hirton | | YM80L | 1 1 1 | | 1 |
| | | | | | | | | | 0 | . 15 | 7 | 15 |
| | .16 | | | | | | | | | .3/ | | |
| مالللا | | | | | | | | | | | | |
| d d | | ENERGE | | | | | | | | | | |
| | Trend tree in | | | | | | | | | Hi | | 1 |
| | .// | | | / | ing. | | | | | | | J. |
| | | | illii k | 340 | | | | | | | | 1:: |
| | | And the American Street Street | 471/ | | | | | | | | | |
| | 1.00 | Hilly | \\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\ | 2.040 | 11111 | | 詽山 | | | | | |
| | | | | | | | | | | | | |
| | 0 | _ | | | | | | | | | | - |
| | ه ا | .1570 | | | | | | | | | | |
| | .04 | | and at \$100 at 1 and 100 to 100 at 100 | 10-11-11-1 | | | | | | ##### 99174 | | |
| | | | | | | | ijΠ | Him | 774 | 1114 | | |
| | | | | | | | | | | | | H |
| | | | | | | | | Charles of the latest and the | | | | |
| the state of the s | | | 30 | • | 141441 | 11/00 | | | THE PERSON | a | | |
| | | | | | 7/47 | An | 1666 | 14-17-41 | | | | |
| | [12] [4] | ********** | | | | | | | | | | 11. |
| | | | | | | | | | | | BEHH | |

238 PREPARED 185 2-21-60 REVISEO _ NON-AXIAL PERFORMANCE

PROPELLER MOMENT REF. T. GILL, W.S. , HILLER AIRCRAFT CORP. ARD-224, 1959 PROPELLER 3 AND DUCT 3 □ :3/4 □ :47/ m, m

JEL 4-11-60 239 PROPELLER 3 AND DUCT ETILT ANGLE 0

-1 - 10A

| CHECKED | | REPUBLIC AVIATION | R | AGE |
|--|---------------|----------------------|-------------|---|
| | | | | |
| | | W- AXIAL PERA | ORMANCE | |
| | | | | |
| | BEF. 7.; G-11 | L, W. J., HILLER, | AIRCRAFT CO | RP ARD-224 1959 |
| | PR | OPELVER 3 MVD | DUCT 4 | |
| | | Pige 78" | | |
| | 0.5 | | | |
| | | | 54MB01 0 | J. J |
| | 3.4 | | | 47/ |
| alle and the first of the first | 23 | | | |
| | | | | And the second of the control of the second |
| | 2 | 37 6.3/4 | | |
| | | | | |
| | 77 | | | |
| | | | | |
| | | 360 | 60° ANGLE 0 | 96° |
| | | | | |

:-1 OA :V. 2/40 FREPARED 18 4-11-60 REPORT NO. PROPERLER 3 AND DUCT 4

1-10*A* . 2/49

| | PREPARED | - Reg | 411-60 | Sie of a start | PAGE | 242 |
|---------------------|------------------|-----------------------------|-----------------------|---|---------------|---------|
| | CHECKED REVISED | | elevin subeneri elizi | TO STATE A SECRETAR OF A PROSECULAR CONTROL OF THE STATE | REPORT HOOEL | NO. |
| | | | | 103 | | |
| | | | | Viole-121/2 PERFORM | Juce III | |
| | | | | POWER | | |
| | | REF | 7;6 | MI, WIT, HULLER ALKE | RAFT CORP | 410-224 |
| | | | | PROVENCER 3 AND | ρυςτ 4 | |
| 1. | | | | 100 | | |
| | | | | | | |
| | | | | | Syngo | |
| | | | | | 0 ./ | 57 |
| | | | | | | 7/ |
| | | | | | | |
| | | /2 | | | | |
| | | | | | | |
| | | -08- | | | | |
| | | والمروبة المناوية والمعروبة | | | | |
| | | | | | | |
| | | | | | | |
| | | | | 60° 1747 AN | 90 | |
| E-1-10A ev. 2/49 | | | | | | |

| PREPARED | 13P 4-11-60 | | | PAGE | 243 |
|-------------------------|--|--|--|-----------|---|
| REVISEO | NUMBER OF STREET OF STREET, ST | edo antigo e estados estados esta estados estados estados estados estados estados estados estados estados esta | ರ್ವಜನಿಯ ಹನ್ನು ಪ್ರಶಾಸಕ್ಕೆ ಗೆಯಲ್ಲಿ ಬಿಸ್ ಪ್ರಶಾಣಕ್ಕೆ | HODEL | (Carl(M)) = 1, (C.) (1) 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 |
| | | | | | |
| | Val | | DANANCE. | | |
| | | SKROVO ZVAT | | | |
| HEF- | é prisit de l'empièment e s'au l'ent i s'al les Angrés de l'entre de la company de la co | UJ HILLER AIRC | | AED-224 3 | 1959. |
| | PROF | 22,28 5 AND | | | |
| | | 10-7R = 10-1-1-1-1 | | | |
| | | | | | |
| | | | SYMBO | | |
| | | | | 314 | |
| | | | | 77/ | |
| | 3 | | | | |
| ╏╧┼╁┦┎┸╘┼┺┈╁┸┼╂┰┼╡╂╁┸╬┤ | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | 600 | -190°. | |
| | | | ANGLE O | | |
| | | | | | interpretations. |

E-1-1JA av. 2/49

| NON-SYML PERFORMANCE LINE DIVISION ARE 7; GILL, W.L., MILLE MERRIT CORP MO-229, PROPERLY 2 440 DET 4 10 SAME TO 314 A 1.47/ OR. OR. OR. OR. OR. OR. OR. OR | CHECKED | | | мэрен | RT NO. |
|--|--|-----------|-----------------------------------|------------------|--------------------------------|
| NON-ATTIC PERFORMANCE LITT DIVISION REE 7. GILL, IN I. MILLER MEASURE COMMARD-224, PROBLER 3 AND DUET 4 REE 18 6 SMOOL T O 167 314 A 171 A 1 | | | | | |
| AND DIVISION REE 7: GUL, W. J. MULIER ARCRITY COMPARINGLY PROPERLY R. J. AND DUCT 4 O 15-17 O 15-17 OR O 4-4 O 4 O 4 O 4 O 4 O 4 O 500 O 700 FILT ANGLE B. | | | | | |
| PROPERTY 3 AND DUET A PROPERTY 3 AND DUET A PROPERTY 3 AND DUET A SYNEOL II O 157 O 314 L L O 306 O 306 O 906 O 906 O THE ANGLE & | | | 10N -5 X111 PEKFO LIFT DNUSTON | 7,7,4,2,NCE | |
| PROPERTY 3 AND DUET A PROPERTY 3 AND DUET A PROPERTY 3 AND DUET A SYNEOL II O 157 O 314 L L O 306 O 306 O 906 O 906 O THE ANGLE & | | | | | |
| 0.6 0.6 0.7 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 | | | | CRAFT CORP AR | |
| 0.6 0.6 0.7 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 | The state of the s | 780 | 870 = 18° | | |
| 0.6 0.4 0.6 0.7 0.7 0.7 0.7 0.7 0.7 0.7 0.7 0.7 0.7 | | | | | |
| 0.6 0.4 0.6 0.7 0.7 0.7 0.7 0.7 0.7 0.7 0.7 0.7 0.7 | | | | S/1980 L S | <u>.</u> 57 . |
| 0.4 0.4 0.00 | | | | Δ | 7/11 |
| 0.4 0.4 0.00 | | 0,8- , | | | |
| 0,4 0 308 609 90° | | | | | |
| 0 30° 70° 40° 50° 70° 60° 50° 60° 50° 60° 50° 60° 60° 60° 60° 60° 60° 60° 60° 60° 6 | | | | | Comment & the same of the con- |
| 30° 509 90° 71'LT ANGLE & | | | | | |
| 30° 50° 90° 7147 ANGLE G | | 10.4 | | | |
| 30° 50° 90° 7147 ANGLE G | | | | | |
| 30° 509 90° 71'LT ANGLE & | | | 1875 T | | |
| 30° 60° 90° 70° 60° 60° 60° 60° 60° 60° 60° 60° 60° 6 | | | | | |
| 4.144 bits a boules to a problem to the property of a property of the prope | | | 300 | 609 9 4NG/E A | o* |

| PREPARED | 4.11%0 | | | MAGE | 245 |
|----------|------------------|-------------------------|--------------------|-------------|--------|
| | | F15 106 | | | |
| | Noneas | אנו אוא אפן אני | MANCE | | |
| | 543 | בניהם פינים | | | |
| rer 7 | ; G122, W.J.; Y. | KLER AIRCRA | ET CORR | ARD-224., I | . ezer |
| 2,3 | PROJ. | 6215K 3 AN Box = 18° | ם Duct | 9 | |
| | | | | | |
| 0.2 | | | 5 <i>7/4/</i> 0 | 157 | |
| 125 | | | ۵ | 77/ | |
| 0.7 | | J | | | |
| 0== | D-G-(3/4) | | | | |
| | | 7/47 | O' ANGLE E | 90° | |
| | | | | | |
| | | | | | |
| o | | | | | |
| -03 | | | | | |
| -0.3. | | | | | |
| | | | | | |

-10 A 2/49

| PREPARED | JES 4-11-60 | | ζ''. · | PAGE - REPORT NG | 246 |
|---|-------------|----------------|-----------|---------------------|-----|
| CONTRACTOR AND STREET | | FIG. 107 | | | |
| | Nov. | EXIM PEPENER | المراردور | | |
| | | NINENTS | | | |
| | 7: 642 | J, HILLER AIRC | eart So. | ee ARD | 224 |
| | Donne | 71 ER 3 440 D | UST 4 | | |
| | | B-18 = 18. | | | |
| | .20 | | 57400 | | |
| | 16 | | 0 | .157 | |
| e | 3 | | | 771 | |
| Transfer in A Links & And House D. Leath & H. | 12 | | | | |
| | | | | | |
| | .08 | | | | |
| | 04 | | | | |
| .0 | 00000 | | | | |
| | | 13/3 | | 90° | |
| | | | | | |

JEL 411-60 247 PAGE PREPARED _ REPORT NO. _ CHECKED MODEL REVISED SYM502 J 314 0.2 -10 A 2/49

Reference

12

Author Source Grose, R. M.

United Aircraft Corporation

Figs.

109-114

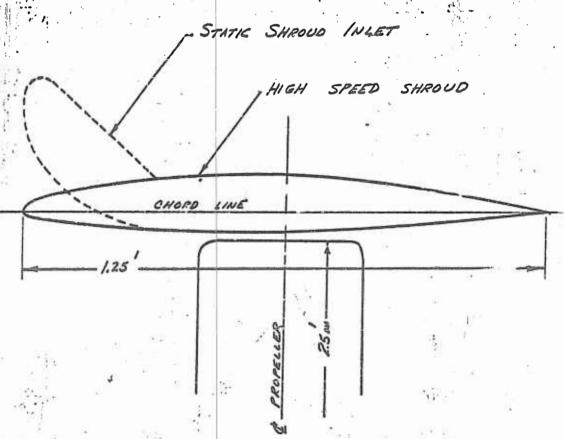
CONFIGURATION

REF. 12; GROSE, R.M., UNITED AIRCRAFT. CORP. (WADE TR 58-604, 1958)

 $\frac{A}{Ac} = .907$

PROPELLER: - 4 BLADE SINGLE ROTATING (HAMILTON STANDARD DIVISION MODEL SK-28175)

SHROUD !



PREPARED 185 1-17-60 250 ιý

| PREPARED | 6-27-60 | (And | PAGE251 |
|--|---------------------|--|--|
| REVISED | | AVIATION / | MODEL |
| | | | |
| \$ H | | | |
| 709 | | | |
| | | | |
| | ejilah muhuma sista | | 2 |
| | | | |
| ORWAL 7 CON | | | |
| | | 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 | |
| | | many decreases and compared to the second of | |
| | | | 9 |
| j j | | \$2,3% | |
| e de la companya de l | | % | |
| | | , s _o | |
| | | | 1914 - Haran III - Haran II - Har |
| | | | \(\frac{1}{2} \) |
| | 7.8 | | |

1 - 1CIA 2 / 49

PREPARED 051 2-16-60 253 $\begin{array}{c|c} M_0 = 0.4 \\ 3R^3 \le \beta_{0.5R} \le 47^{\circ} \\ \hline & B_1 D_1 D_2 \end{array}$ 0

2/ 49

254 PREFAREN REPUBLIC AVIATION REPORT NO A 0 บ M 1 CER 7, 0 20 :::[:::: 900 20 Q 80 0 R.75R 10 o T 0 111 1.0 400 .60 35 0 0 0 · tı 10 h Ö 0 1 - 10A REV. 2/49 Hill

Reference

60

Author Source

Platt, R. J. NACA

Figs.

115-121

| | | EGKEES | 6.) p. | | | 7.2 |
|----------|-------------------|-----------------|---------------------|------------------|---------------|---|
| | | AE/A | <i>``</i> | | <i>w</i> . | ×. |
| | 3401. | PES | 0.671 | | 0.671 | 0.836 |
| | | ŧ | V | | | 9 |
| | S 1 H 25 | Cs | 32.2 | * | 32.2 | 40.1 |
| | 57 | . ` | • | | | , |
| | J., NACA RM | | | | | |
| F16. 115 | VACA | 4 | | • | | ā \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ |
| F1G. | COURTIONS | IRFAC | | JES | | SURFACE |
| | 13 0 | . INNER SURFACE | Λ | PROPELLER PLANES | 0 / v | ~ / / |
| | SHROUD ; PLATT | INI | 0000 | PFLLER | SHROUD | SHROUD |
| | 09 | | SHI | 0000 | / 1 | 1 1 |
| | REF | | RUISE | À | AKEOF | TAKEOFF |
| | | | SHORT CRUISE SHROUD | 7 | SHORT TAKEOFF | 4 4 1 |
| | 12 | 1 | 540 | | SHO | Long |
| | | | 1 1 | | 1 1 | 1 1 |

ALFO 185 1-17-60 257 SHROUD Z STATIC PERFORMANCE

RATTIRE JR. MACA RM

SHORT, TAKEOF

SHORT, A.S.

S

1 - 10A

| PREPARED | -gsx 2-17-0 | 00 | | 1 | | | | PAGE | | 258 |
|------------|---|---------------|-------------------|-------------------------------|-------------------|----------|-----------------------------|--------------|------------------|------------|
| CHECKED | | _ | (m) | REPUBLIC | | | • | REPORT | NO | |
| NEVISKO | | _ | | • • | | | | MODEL | | |
| | | | | | | | | | | |
| | | | FIG | 117 | 7. | | | | | |
| | | | | | | | | | | - |
| | | <u>57A</u> 7 | r/C | PERFO | PMAN | ICE | | | | |
| | SHRO | UD PR. | 5550 | RE L | 21511 | 71.80 | 1.101 | | | |
| 7 | O AEF 60 | ; PLATT, | R.L. | NACA | RM | <u> </u> | H25 | , 19 | 48 | 40 (00) (|
| | 9 | | 1 | | | | | | | 7-7 |
| 1 2 1 2 1 | | SHOP | 7 | AKEC | FF | SHR | 000 | | 111. 11. (H.) | |
| | | | | | | | E E | | | |
| | | | | 1:4:42:31 | | | | | | <u> </u> |
| 18 | | | | HELE | | | | | | |
| - 4 | | | | | | | | erjer. | | |
| 5 | 100000000000000000000000000000000000000 | | / ₀ = | P | Po | | | | | 7 |
| N. I | | | 1 | pnz | d ^a :: | | | | | |
| | | | | Hill | | | | | | |
| 1-0 | | | | | | | | | | |
| N L | | | 17:11:11 | | | | | | | |
| 7 | | | | | | | | | 117 102 T | |
| | | | 11 11 11 | | | | | | -, <u>u</u> | |
| | | | | | | 1. | | | | |
| W=3 | 6 | | 1 | OUTER | SUL | RFACE | | | | |
| | | / | | | | | | | | |
| N N | T Q | | T, | NNER | 508 | FAC | <u> </u> | | - 151 | |
| 0-2 | <u> </u> | | | | | | | | 2423 | |
| | | 0/ | 153.3 | | | | | | | |
| | | | | | | | | | | - |
| | | 10- | O. | | | | | | | |
| | | | - ⁶ 00 | 0\ | | | 1247611. | # ## r | | |
| | | | | 0 | | | | | | |
| | | | | | 0 | | | | | 1 |
| | | | | | | 10 | $\stackrel{\smile}{\smile}$ | | | |
| | 0.2 | in district a | 0.44 1.44 | 0.0 | , | 0.8 | | | 2 | |
| | | | | page of the firm and the con- | s I | | | | | |
| | | FRONT | REAR | | | | | | | |
| | | PROPELL | ERS | | | | | | | |

| PREPARED _ PREPARED | 2:23-60 | | PAGE | 259 |
|--|---|-----------------------------------|----------------|-------|
| CHECKED | | REPUBLIC | REPORT NO. | |
| REVISIO | a to the state of | AVIATION | MODEL. | |
| | | | | |
| | | G //8 | | |
| | | PERFORMANCE OCITY DISTRIBUTION | /s. | |
| RET | 60; PLATT, P.J., | NACA RM 17H25 | , 1948 | |
| | SHORT | CRUISE SHROUD | | |
| | | 0-2600 RPM | | |
| Company of the party of the par | PROPELLERS | LOCATED AT 0.3 | SAND 4 | 14 C, |
| //0 | | | | |
| | | OF PROPELLERS | | |
| 0.8 | | ./34 c _s) | | |
| N tip | DOWNSTR | EAM OF PROPELLERS | | |
| 0.6 | | | | |
| | | | / | |
| 0.4 | | | | |
| | DYWAMOMETER SURFACE | | | |
| 0.2 | | | HROUD REACE | |
| | | | | |
| | 0.2 | 04 06 0 | | 0 |
| | | 79 | | |

E -1 - 10A SEV. 3/ 49

260 450 J 0 8 400 DO 20 Fr. Sukoup 0 Ú I Ó Ö 0 Ö SE. 603 26

- 10A HL - 2/49

Staf 23:4-60 261 SHROOD REAR ONG, TAKEOFF SHORT, CRUISE NSHR OUDED 4 0 O 120 SEMOSS BLADES ONENT 0 0 0

1 · 10A 3/ =9 grd 22460 262 SHROUD SHORT, CRUISE LONG, TAKEOFF SHORT, TAKEOFF CRUISE 400 < □ ◊ ROWT COMPONE POWER 25,00035 00

+1 - 10A V, Z/49 Reference

31

Author Source

Kruger, W.
AVA Goettingen, Germany

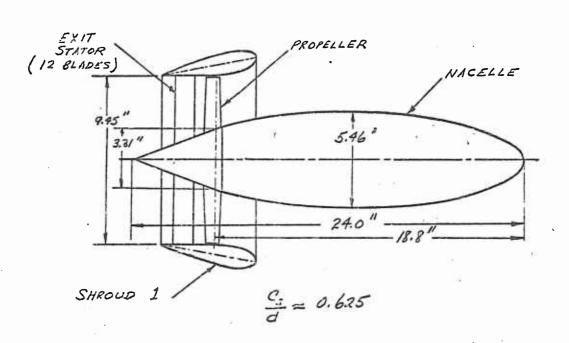
Figs.

122-130

FIG. 122

CONFIGURATION

REF. 31; KRUGER, W. ZWB FORSCHUNGSBERICHT NR 1949 (NACA TM 1202, 1949)



265 JBS 1-18-60 6261 SPLIT RING 000 Œ , , , 450 8 NOSE 0___ 0 108S WITH 1 WITH EXIT STATOR 20 tr v O ZNB SHROUP 50 SHROUP SHROUD 1 80/38 350 0 Sypour 0 65.00 O O,

1-18-60 PREPARED ___ J85 266 65 TRICHT. 74707 (O), · . ; Û. 0 () 10 NCE PERFORMA 000 ZWB 1202 0 21 o 35 0 17 0 0 7s7

-1 - 10A -V. 2/49

267 PHEPAHED 185 -18-60 REPORT NO. . 0 4 o. . Q. 2 I U 8 S **U** 2.55 REORMANCE co. ×: : O ::: 0 2.0 0.0 0.0 0.0 3 S C 4 ۳ <u>-</u> r d BN 88 WRUGER, W.
NAGATHO 30 00 0 100 Ö 0. 0 9

-1 - 10A /, 2/49

Jes 4-25-60 268 PEF 31; KRÜGER, W. TWB FORSCHUNGS (NACA TM: 1202, 1999) PROPELLER 1: (8 BLADES)

| PHEPARED | 92 | 4.25-60 | , | | | 12.16 | | | | PAGE | | 269_ | |
|-------------------------------|----------------|---------|--------|-----------------|--|----------------------|--------------|--------------|---|-------------------------------------|--------|------|-----|
| CHECKED | | | | | (20 | REPUBLIC AVIATION | | | | REPORT | NO | | _ |
| atvised | | | | | | | | | | VODEL . | | | |
| | | | | | المنابعة الم | J27 | | | | · p.b.; id.; | | | |
| | | | | | 10- | | | | 1 | | | | |
| | | | AXIA | 4 | ERF | ORMI | سے سے | | | | | | - |
| | | | | | | | | | | | | | - |
| - Pe | پر کا <u>.</u> | KRII: | of the | 1 10 | W3_ | FORS | CHUL | VGSE. | ERIGHT | | o. /9. | 9. | - |
| | | | | | | 7272 | | | | | | | |
| | | PR | PELL | EP. | / (| 8 6. | ADES |) WI | 111 51 | 1800L | 2 | | |
| | | | A | ND_ | EXE | 57 | TUR | | | | | | |
| | | | | 114112 11412 | | | | | | | | | |
| | | | | | | | | | 17440 E-160 12750 E-160 17750 E-160 | | 1441 | | 1 |
| | | | | | | | | | | | | | - |
| | | | | | | | | | | | | | - |
| | | | | | - 1414 | | | | SYMEO | <u> </u> | B.75R | | - |
| | | | | | | | | | o | | 35° | | |
| 1.6 | | | | | | | 1.1.11 | | -0 | | -50° | | - |
| $ \mathcal{L} _{\mathcal{K}}$ | , | | | | | | | | A | | 65° | | 1 |
| 17 | | | | | | | 22135 | | | | | | - |
| 1.2 | | | | | | | | | | | | | + |
| | | 7 | | | | | | | | | | | 1 |
| | Q :::: | 14 | | 1 | | | - 151 | | | | | | - |
| 0.8 | | / /9 | (: | [| 1) | | | | | | | | |
| | \sim | 1/ | 1 | 1 | / | | | | | | | | |
| | 2-6 | 1/ | | | 1-69 | $\overline{}$ | 1 | | | | | | 1 |
| | | - | A 🖸 | \bigvee | 17 | p (A) | $\langle - $ | | | | | - 1 | 1 |
| 0.4 | | 11 | | X | | 50 | 765 | ا الله | | | | | |
| | | 116 | 3// | | X | | 3 | (111) | | And the second of the second of the | | | |
| | | | -/2 | , 0 | \sim | 50° | ijsr. | | 海绵的 美国化化学 | a Desperation | | | |
| | | | - 4 | 35 | | 0.3 | | | | | | | 100 |
| | | | | | 7 | | 7 | Hall A | 닏Ш | | | | 1 |
| | | | | | ADVA | NCE | KAT | 10 | | | | | |
| | | | | | | | | | | | | | |

-1-10A V, 2/40

4.25.60 270 REF 31; KRÜGER, W., ZWB FORSCHUNGSE (NICA TN 1202, 1949) PROPELLER 1 (8 BLADES) WITH SHADUD 1 ANO EXIT STATOR

-1 -10A V. 3/49

PREPARED 500 0.11 2.6 = 7.80 0 Source of a 0

E -1 - 10A EV. 2/49

PHERAPEO PR 4-26-65 272 REF 31; KRUGER, W (NACA TM 1202, 1949) AHEAD OF THE PROPELLER SHROUD 1 AND OR PROPETLER 1 (8 BLADES) 7. \(\bar{\pi}\) SYMBOL CONDITION $0 \qquad W_{17HOUT} = PROPELLER$ $0 \qquad J = .120 \quad C_{7} = .230$ $0 \qquad J = .629 \quad C_{7} = 6.18$ $\Delta \qquad J = 1.92 \quad C_{7} = 0.24$ -1-10A V. 2/49

Reference

80, 81

Author Source

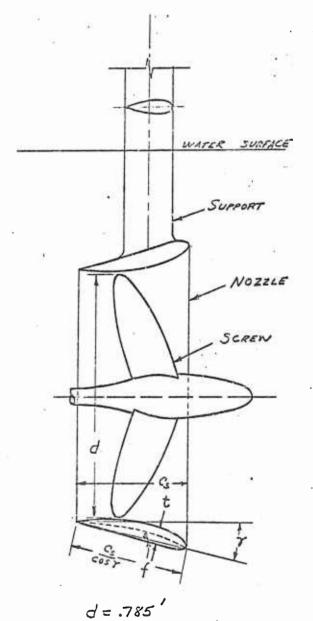
Van Manen, J. D. Wageningen, Holland

Figs.

131-138

SHROUD CONFIGURATIONS

REF. 80,81; WAN MANEN, J. D. , PUBL. NE 11500 NISME, WAGENINGEN, 1954



| NOZZLE | deos's | t cos y | fcos v | 8 | PRO | F/LE |
|------------|--------|---------|---------|--------|---------|--------------|
| 1 | 1.00 | AXIA | L CIRCU | LAR CY | LINDER | |
| 2 | 0.67 | 0.15 | 0.04 | 12.7° | NACA | 4415 |
| 3 | 0.50 | 0.15 | 0.04 | 12.70 | NACA | 4415 |
| 4 | 0.83 | 0.15 | 0.04 | 12.70 | NACA | 44:5 |
| <i>5</i> ° | 0.50 | 0.15 | 0.04 | 15.2° | | 4415 |
| 6 | 0.50 | 0.15 | 0.04 | 10.20 | NACA | 4415 |
| 7 | 0.50 | 0.15 | 0.05 | 12.70 | | P NACA STIS |
| 8 | 0.50 | 0.15 | 0.03 | 12.70 | BUILT U | P "WACA SHIS |

132 3-2-60 275 □ **◇ → ⊿** 132 WCY (15a) 10.EW 77.6 500. 8 4 ď 30 0 1 0,2 0.0

からなり 一切

-10A

M3M8.5 S 2 2 8 6 M S 2 2 M 8 0 M VAN MANEWS 0

E -1 - 10A EV. 2/49

278 CHECKED _ 1022EL 708 MXS THRUST OVINSTANCE

SERVING

STATE

ST o · - 12. Mak 0 9 % Ó

-10A

3-21-6 279 MODIEL 7 E RECORMANS 55 SERIES SCREW

NOTILE VO 1

CIRCULAR CHIMOER)

50

50 1110 Scee 1 7 5 7 DVANCE 12 5 B 4-5 WITH (AXIAL .40 O H 8 4.0 20 Zio 0 W 0 0 10.0

E +1 - 10A EV. 2/49

PHEPARED 181 3-3-60 230 AXIAL PERFORMANCE EFFICIENCY REF. 81; VAN MANEN, J.D. PUBL. NO. 1150 NSMB, WICENINGEN, 1954 4-55 SERIES SCREW 210 14.30 0.57 20 0.50 0.30 0.4 0.8 0.8 ADVANCE RATIO J 1.2 PREPARED JRS 3-4-60 281 EFFICIENCY PAT. 81 VAN MANEN, J.D. PUBL NO. 115 a. NSMB, WAGENINGEN, 1954 B 4-55 SCREW SERIES WITH NOZZLE NO 3

2/49

Reference

1

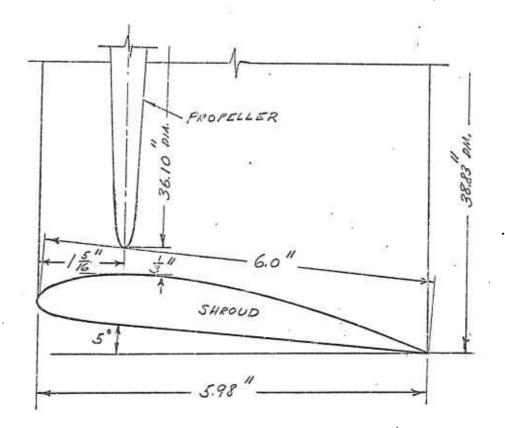
Authors Source Allen, H. J. and Rogallo, F. M. Stanford University

Figs.

139-141

SHROUD CONFIGURATION

REF. 1; ALLEN, H.J., ROGALLO, F.M.
RING COWLED PROPELLERS, THESIS, STANFORD U., 1935



FREFARED 058 4.20-60 284 PAGE REPORT NO. MODEL , ALLEN, H.J., ROGALIO, F.M. RING COULED PROPELLERS, THESIS, STANFORD PROPELLER A WITH SHROUD Bi7R = 25.4 - PROPELLER 0.40 0,0.75 0.8 E-1-10A

FREPAREC 10 4-20-50 235 PACE CHECKED ____ REFORT NO. REVISED __. MODEL RING COWLER PROPELLERS, THESIS, STANFORD U. 1935 PROPELIER A UNSUROUDED 10 0.20. 0.70 0.80 0.70-0.60 0.40 .0.20 06 1.0 ADVANCE RATIO

E-1-104 Rev. 2/49 Reference

52

Authors Source Moser, H. H., Livingston, C. L.

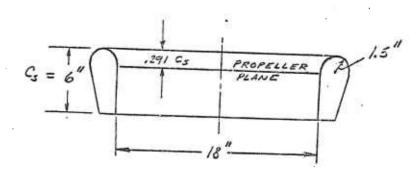
MIT

Figs.

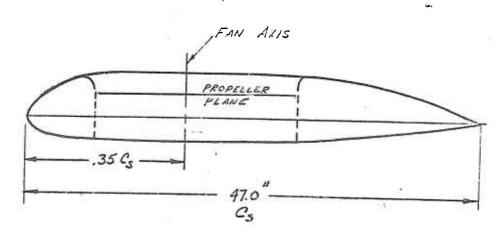
142-151

CONFIGURATION

REP. 52; MOSER, A. H. & LOWINGSTON, C.L. MIT TR 79-1, 1959



TILTING MODEL



WING MODEL ASPECT RATIO = .766

288 METATED 185 1-21-60 (N) V SZIZ III ADE. SHE 0 0 8 7st

E - 1 - 10A EY, 2/49

1

Pr 4-27-60 289 NOES 73 1 0 Ö. 0

-1 - 10A

Jel 4-29 60 290 0.3

PRE-AREO PL 1-29-61 291 REF. 52; MOSER, II.H., LIVINGSTON NIT TR 79-1, 1959 UNTWISTED BLADES BE

10A

r 00000 9/ 4-29-60 FIG. 147 FIN-IN-WING PERFORMANCE
POWER REF 52; MOSER, H.H., LIVINGSTON, C.L. MIT TR 79-1, 1959 INTWISTED BLADES BR = 200 358

E - 104 EV 2/45

BS : 1-2760 293 PITCHING MOMENT REF. 52; MOSER, IIH., LIVINGSTON, C.L. MIT TR 79-1, 1959 UNTUISTED BLADES 3, 200

6.5V 2/41

PS 4-28-60 294 F1G. 149 STATIC PERFORMANCE GROUND EFFECT REF. 52; MOSER, H. H., LIVINGSTON, C.L. MIT TR 79-1, 1959 WING MODEL LO = 21.8 18/F72 TILTING MODEL Los = 23.4 18/E72 0.4

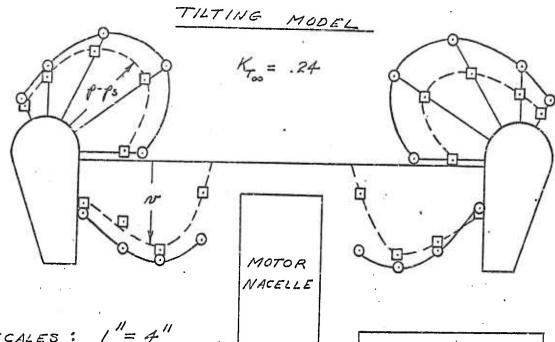
Jed 4-21-60 295 REPORT NO FIG 150 GROUND EFFECT CONSTANT POWER REK 52; MOSER, H.H., LININGSTON, C.L. MIT TR 79-1, 1959 -1.2-WING MODEL -

F +1 -10A

FIG 151 (a)

STATIC PERFORMANCE REF. 52 EFFECT OF THE GROUND ON INFLOW VELOCITY AND DUCT PRESSURE DISTRIBUTION

UNTWISTED BLADES BISE 250



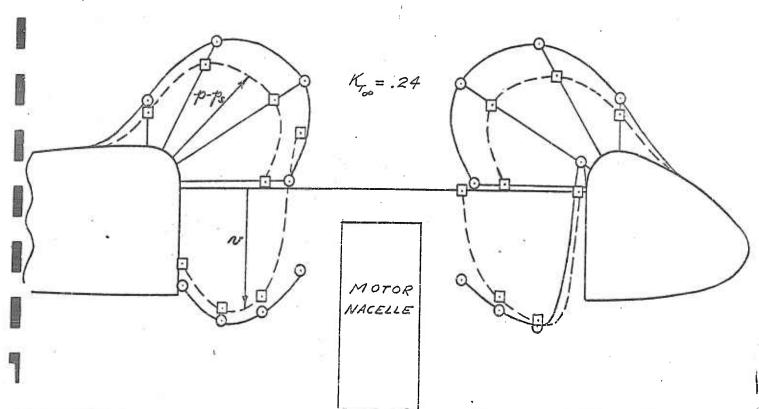
SCALES: 1 = 4"

p-ps 1"= 37.0 18/F72

NWING 1" = 85.0 FT/SEC

NTILTING 1 = 107 PISE WING MODEL FIG. 151 (b)

h/d = .57- h/d = 00



Reference

74

Author Source

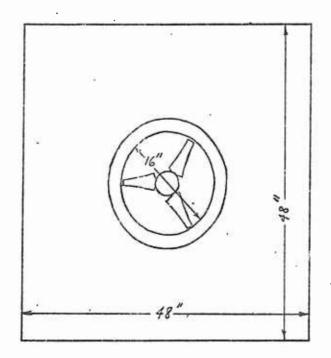
Taylor, R. T. NACA

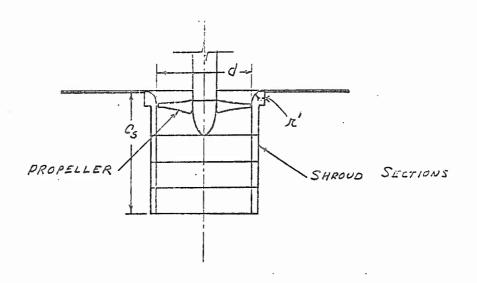
Figs.

152-154

FIG. 152 CONFIGURATION

REF. 74; TANZOR, R.T., NACH TN 4126, 1958





| CHECKED | 93P 4-2860 | | PAGE |
|---------|------------|-----------------|---------------------|
| | | F/G 1.53 | |
| | | TATIC PERFORM | MOS |
| | FFEECT | OF SHROUD INCE | PARIOS OF |
| | | | 1 TN 4126 , 1958 |
| | | | |
| | | Cs ~ 1.0 | |
| | | 7 7 | |
| 1.0 | | | |
| | | | |
| 7.8 | | | |
| 7 | | | |
| 0,6 | | MPLI: MOMENTUM | THEORY ME=1.0 Cpc=0 |
| | | 0 | |
| 0.4 | 10 | | |
| | | | |
| 0.2 | | | |
| | | | |
| 0 | | | |
| | .02 | .04 .06 11/d | .12 |
| | | | |

. E-1-111 Fev. 2/49

300 EFFECT OF SHROUD DIFFUSION ON THEUST PIVISION REF. 74; TAYLOR, RT. NACA TN 4126, 1958

Reference

47

Authors Source

McLemore, H. C., and Cannon, M. D.

NACA

Figs.

155-167

ro ysl 4-27-60 302 EFFICIENCY

REF 47; Mclewore, H.C., CANNON, M.D.

NACH TN 3228; 1954 d = 5:33

303 PRECINED SES 1-5-60 FORCE CHARACTERISTICS REF. 47; MCLEMORE, H.C., CANNON, M.D. NACH TN 3228, 1954 J = 1.0 J=3.0

DATES _____ 930 5-18-60 304 NON-AXIAL PERFORMANCE RESULTANT FORCE
REF. 91; McLEMORE, H.C., CANNON, M.D., NACA TN 3228, 1954 UNSHROUDED PROPELLER K_R 30° TILT ANGLE O

| PREPARED | - Off | 2-18-60 | N. V. | | PAGE | 305 |
|----------------|-----------------------|---|--------------------------------------|------------|---------------------|--|
| CHECKED | · | | REPUBLIC AVIATION | | REPORT N | · |
| REVISEO | | terminan to surprise | The same | | MODEL | |
| | | | FIG. 158 | | | |
| | | | | | | |
| | | | ON- AXIAL PERFORM | ANCE | | |
| | RE | F.47; McL | EMONE, H.C., CANNON, | Y.D., NAC. | 4 770 | 3228, 195. |
| | | | UNSHROUDED PR | 11 | | |
| | 1,2 | | B ₁₁₅₀ = 30° | | | A STATE OF THE STA |
| | | | | | | |
| | | | $C_R = \frac{R}{P \sqrt{2} \pi d^2}$ | | | |
| | /-0- | | | | 111.7 | to being to |
| | | | | | 0 | the second second |
| | -0.8 | THE REAL PROPERTY OF THE PARTY | | | Tree la | 3.0 |
| C _R | 4 1 10 1 10 10 10 | | | | | |
| | 06 | | | | | |
| | | | | | | |
| | 1 | | | | | |
| | 0.4 | | |) a | | |
| | | | 4 | | | |
| | 0.2 | | 3.0 | | | |
| | to a part of the same | | 3.0 | | mental market party | |
| | | | | | | |
| | 0 | | 30° 60° 60° | θ | 90 | 2 |
| | | | 1/LT ENGLE | | | |

· 10A 2/49 !

306 PRUPARED 185 -1/2-66 FORCE CHARACTERISTICS B.750 - 30° REF. 47; NACA TN 3228 0.4 TILT ANGLE E - 10A

MER-MED 185 1-665 3.07 FIG 160 EFFECT OF THE ANGLE ON THRUST AND POWER - REA 17; NACA TN 3228

-1-104

| PREPAI | 100 | Jones ! | 2-14-6 | 20 | ١ | - (- | | | | | PAGE | 3 | 08 |
|--------|----------------|---------|--|-----------------|--------|---------------|-------------|---------------------------------------|--------|-------------------------------|--|------|----|
| CHECK | | | | _ | | 1-30 | HEILENA | | | | REPORT | NO | |
| | | | | | | FIG | 16 | | | | | | |
| | | | | NO. | V-11. | YIAL | PE | RFO | RMA | NCE | 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 | | |
| | | | FZ- 17 | M | 1.1 | 1 | N75 | 20.0 | MD | NA | CA TI | 1322 | |
| | | | | | | | | 1 1 1 1 1 1 1 1 1 1 | | (-1 a) (-1 a) (-1 a) | | | |
| | | | | | UNSI | 1 | ?== | 30 | ROP | 5/1E | 77 <u>- - </u> - <u>- - </u> | | |
| | | | | | | | 75.R | | | | | | |
| | | 0.5 | | A | | | | 1. 7 | | ٤ | VMBOL | J | |
| | | | | /:::\ /::::\ | \ | | | | | | 0 = . ================================== | -1.4 | |
| 1.11 | | 0.4 | | | | 3.0/ | <u> </u> | | | | Δ | 3.0 |) |
| | <u>e</u> | | | | \ | / | | | | | | | |
| | d | -0.3 | <u> </u> | | | 154 | | | | | | | : |
| | | | | | _\t | /_ | ور | | | | | | |
| | | -0.2- | | | C | | d : ⊞ .o | | | | | | |
| | | | | | | | -0 | | | | | | |
| | <u>ुः</u> व | -0.1- | AT AT | _A- | 4 6 | <u></u> | - | 4 | | \ <u>a</u> | | | |
| | | | | | e. | | `∆ 3. | o J o I | | | | | |
| | | i o | | | 3. | | | 6 | a° iii | | 9 |) | |
| | | | | | | <i>(1</i> .7. | ANG | | 9 | | | | |
| | | | | | 54431 | | | | | | | 591 | |

| PREPAIRO | CBJ. | <i>3-19-60</i> | | P. P. R. P. AV | PHSLIC IATION | . % | | PAGE | 309 |
|----------|------|----------------|---|----------------|------------------|--------|----|-------------------------|------------|
| | | | | -IG | 162 | | | | |
| | | 51 NC | W-AX | MLF | PER | FORMAN | CE | | |
| | | | RESUL. | TANT | FO | ACE | | | 720 100 |
| | | | | | | PROPE | | | 228 , 1954 |
| | 1.2 | | | B.75 F | 2 | 400 | | | |
| | | | 4 | (R = - | R | J+ | | 100 | |
| | 1.0. | | | | | | | Бумвос | |
| | | | | | | | | - 0 - 0 - 0 | |
| | 0.8- | | 7.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1 | | | | | Δ | 3.0 |
| K, | | | | | | | | | |
| | 0.6 | | | | | | | | |
| | | | | | X | | | and the same to be | |
| | 0.4 | | | | | | | | |
| | | | | | -6 <u>\</u> | 3.0 | | | r i i i |
| | 0.2- | | | | | 9 | 0 | o | 1.4 |
| | | | | | | | | | |
| | -0 | | 3 | o° | | 60° | | 90 11 90 | |
| | | | | 7/47 | | NGLE | | | |

.

310 REF. 47; MCLEMORE, H.C., CANNON, M.D., NACA TN 3228, 1954 UNSHROUDED PROPELLER B.75R = 40°

E 10A

311 JES 1-6-60 F16. 164 CHARACTERISTICS B.75R = 40° REF. 47; MACA TN 3228 } 30

E -1 - 10A EV. 2/49

| | -93L 2-19-6 | , | (| | 7.5 | PAGE | 3 |
|----------------|-------------|---------|-----------|------------|------|--------|----------|
| REVISES | | • | PEFUENC | | | MODEL | 10000000 |
| | | | F15, 1 | 5.5 | | | |
| | | | | RFORMAI | VCE | | |
| | | | MOMENT | | | | |
| | REF. 97; Mc | LEMORE, | H.C., CAN | NON, M.D., | NACA | TN.32. | 28, |
| | | UNSHK | OUDED | PROPELI | ER | | |
| | | | B.75N= | 40° | | | |
| | | | | | Sv | M801 | J |
| | 0.5 | | | | | | 1,0 |
| | | | | | | | .0 |
| | 0.4 | | | | | | |
| e, | | 4 | | ∆ 3.0 | | | |
| | | | | | | | |
| | | | | | | | |
| e _w | 0.2 | | | 3 | | | |
| | | | | 1 | | | |
| | 0.1 | | | | वि | | |
| | | 8- 2 | 2 en/a | | 2/ | | |
| | | 3 | o°. | 60° | 6 | 500 | |
| | | | T ANG | | | | |
| | | | | | | | |

PREPARED 3BS 1-660 313 FIG. 166 EQUILIBRIUM CHARACTERISTICS AT CONSTANT LIFT 6.75R -30° 100 200 300 REFST; NACA IN 3228

11 - 10A 1. 2/49

1 1 AV

| PREPARED | 762 | 1-6- | 60 | | | 2963 | | | | PAGE | | 31 |
|-------------------------|----------|---------------|-------------|---------|------------|--------------------------------|-----------------|-----------|-------------------|---------|-------|-------|
| CHECKED | | | | | (200 | FEPUSLIC | | | | REPORT | NO | |
| FEVISEO | 7: 1:::1 | | | | 111. 10.1 | , m m; 1 1; . | (Tropped) | director. | | MODEL . | | |
| | | | | | G | 167 | | | | | | |
| | | | | | | gaile. | | | | | | |
| | EQU | ILIBRIU | IM C | HARA | TEK | 7/57/0 | SA | Cal | VSTAN | T L | IFT | ; 12. |
| (0) | | Kp | -0 | M | | 75 | | | | 90 | 18/- | |
| | | | | | 11 | | | 4 | | | | |
| | 20 | | 05F, 4 | 1 . 110 | 1Col = | TN 3 | 228 | | | | | |
| | | | | | 1.45 | | | | | | | |
| | | | | | 100 | $\stackrel{\longleftarrow}{=}$ | 0 | | | | | |
| | 12 | | | / | | | | | | | | |
| | 70 | | راال | 5 | | | | | | | | |
| | | | | | | | | | | | 107.4 | |
| | .04 | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | 1.0 | | 2 | 0. | | 3.0 | | 4- | 0 | |
| 7 5 | | | | H 1995 | | | | | | | | |
| | (o', | | | | | | | | | | | |
| | | | | | PR | | | <u></u> g | 5-10 | VANCII | VG_B | 14: |
| | | | | | > | | | | The second second | TREAT | 17.7 | 100 |
| P.75R | 00 | | | | 10 | | ه ₇₅ | ((| SHIVE | | | |
| g_a' | | | | | | 0/ | | | FIG | 17.8 | | ::- |
| \mathscr{G}_{κ}' | | | | 1 | 1,50 | / i | | | | | | |
| | 200 | | | | (/ | | | -1,75 | 77-77-0 | 7 | | |
| | | \rightarrow | 50 / | 50/ | | | | | | | | |
| | | | | | ϕ_{a} | | | | | | | |
| | | | | | | | | | | | | |
| | | | 1.0 | | 2. | O | | 3.0 | | 7. | 0 | |
| | | | | | | | | | | | | |
| | | | | | | HHE | | | | | | 1 |

PETPACED 385 1-7-60



REPORT NO

FIG. 168 75% RADIUS SECTION ANGLE ADVANCING tan 757 + cos 0 RETREATING 20 30° 400 N= 7511nd 50° BisR 600 70° 80° 90° RETREATING BLADE -30° 4.0 Pa = B.15R ADVANCING BLADE 900 80° €0° 70° No 60° 50° 40° 30° 20 6.0 100

| PREPARED | Jal 5-6-60 | a de | PAGE316 |
|---------------------------|-------------------------|---|--|
| CHECKED | | REPUBLIC AVIATION | REPORT NO. |
| DEVISED | | | MODEL |
| | | FIG 169 URACTERISTICS OF | |
| | AND HIGH ANGLE | SPEED SHROUDS S OF ATTAC $\overline{C}_{L} = \frac{L}{g_{0}}C_{3}C_{3}$ | |
| | Sympor Rever | HILLER ARD-224 | D, B, S B, E 9 A = 0.15 GET TR 58-604 G Bise 22 Mo = 0.2 Bise 30 J=1.0,14 |
| .20 | Δ <i>4-7</i> / | MACA TN. 3228 | B ₋₁₅₆ = 36° T= 1.0,1.4 |
| 700 JU | PROPELLER WTH SHRIGE | ję, | ROPELLER WITH SHROUD |
|) /c 0 3 3 08 | 3 ELSHROUP O | O - CP O - SOLITED O | ROPELLER IN SHROUD SHROUD ISOLATED |
| 06 | N⊡PROPELIER ISOLASED | PROPE | LER IN SHROUD |
| 0 | Δ <u> </u> | 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 | COPELLER ISPLATED |
| | Fower | COEFFICIENT | Kp. |

A. A.

大学の大

PREPARIO PL 4-21-60 317 EFFECT OF TIP CLEAPANCE ON SHROUD
THRUST AND PROPELLER POWER RET. 26; HUSBARD, H.H. WACA TN 2024 , 1950 5/18/000 B (MODIFIED NACA 4315) TIP CLEARANCE

2/49

STATIC PERFORMANCE OF STHIPLE CASCADES

REF. 76; MCKINNEY, M.O.; TOSTI, L.P.; DAVENFORT, E.E. NACA TN 3198

(1954)

| | | • |
|--------------|---------|-------|
| | \ \ \ \ | • |
| | | |
| - | D | |
| -4 | - D | |
| _ | 1 - 1 | |
| | . //// | |
| | I WEW | GIGHT |

| | | | 11 11 | V = WEIG | <i>~</i> / |
|----------|------|------------|----------|----------------|---------------|
| CONFIGUR | | g' deg, | <u>+</u> | . D | $\frac{W}{T}$ |
| 3333333 | / | 7.5 | 0.92 | 0.88 | 0.92 |
| 20/10 | 2 | 12.5 | .83 | .82 | .85 |
| | 3 | 5.0 | .85 | .93 . | . 85 |
| | 4 | 38.9 | .54 | .56 | .69 |
| | 4P2* | 28.2 | 68 | .64 | .77 |
| | 5 | 27.7 | .66 | .65 | .75 |
| \Box | 5°R | 21.2 | .75 | .71 | .81 |
| 5 | 6 | 21,3 | .66 | .74 | .71 |
| | 6 PL | //.9 | .81 | ,83 | .82 |
| <u> </u> | 7 | 20.2 | .65 | .76 | .69 |
| | 7 PL | 13.6 | .78 | .81 | .80 |

^{*} PL DESIGNATES END PLATES WHICH ARE
SHOUN DOTTED IN THE SKETCHES

| CHECKED - GEN | 4.28-60 | REPUBLIC AVIATIOS | PAGE 319 REPORT HO. |
|----------------|-------------|--|--|
| | | G 172 C PERFORMANCE | |
| 1.8 | GROUND EFF. | CONSTANT | Powez s |
| 14- | | | |
| Z 00 (") | | | <u>_</u> Δ |
| 0,8 J | | | |
| 22 | | | |
| -0, | | 3 4 h/d RET 15 FAN: IN-W | ING (23) = 50 |
| -0.6 | | 0 74 FAM-TN-LA | ege 45) = .50 |
| -0.8 -/0 0 | | ☐ 16 FAN-IN-WING \$ 9 TANDEM DUCT \$ 53 DUCTED FAN 71 HELICOPTER, | (1) (1) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2 |
| | | | |